EXHIBIT A

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Woods et al.

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(54) **SYSTEMS AND METHODS FOR COMPARATIVE GEOFENCING**

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G06F 15/16 (2006.01)
H04W 4/02 (2009.01)
H04L 29/08 (2006.01)

(52) **U.S. Cl.**
CPC ***H04W 4/028*** (2013.01); ***H04W 4/021*** (2013.01); *H04L 67/18* (2013.01)

(58) **Field of Classification Search**
USPC 709/204; 455/456.3, 456.1; 701/465
See application file for complete search history.

(56) **References Cited**

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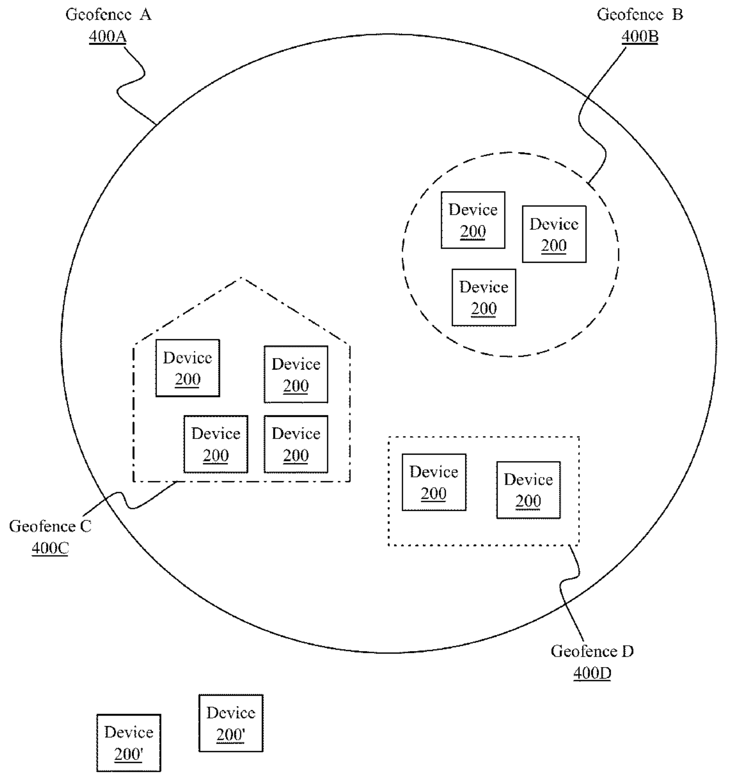
(57) **ABSTRACT**

The present disclosure describes systems and methods for time-based geolocation queries, with designated planned arrival and/or departure times or event start/end times. The number of queries can be drastically reduced to reduce battery, bandwidth, and processing requirements; or the rate of queries can be increased within a specified time frame, providing much higher resolution of geolocation information. Geolocation information may be monitored via notifications from portable devices to identify demographics of users within identified regions and subregions, allowing real-time, dynamic comparison of demographic information between locations, such as restaurants, clubs, or events.

20 Claims, 13 Drawing Sheets



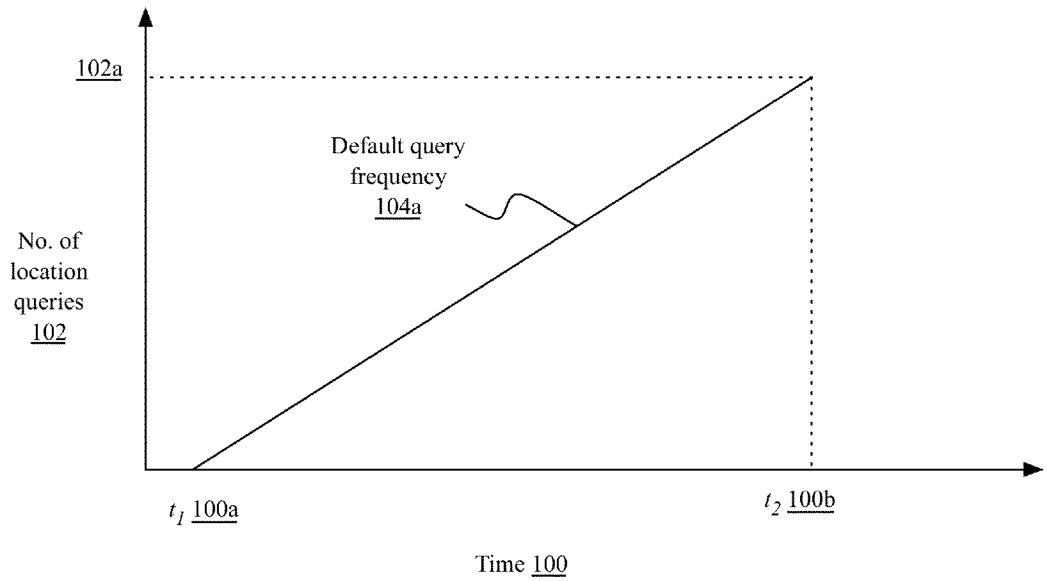

102a
Default query frequency 104a
No. of location queries 102
t_1 100a
t_2 100b
Time 100

FIG. 1A

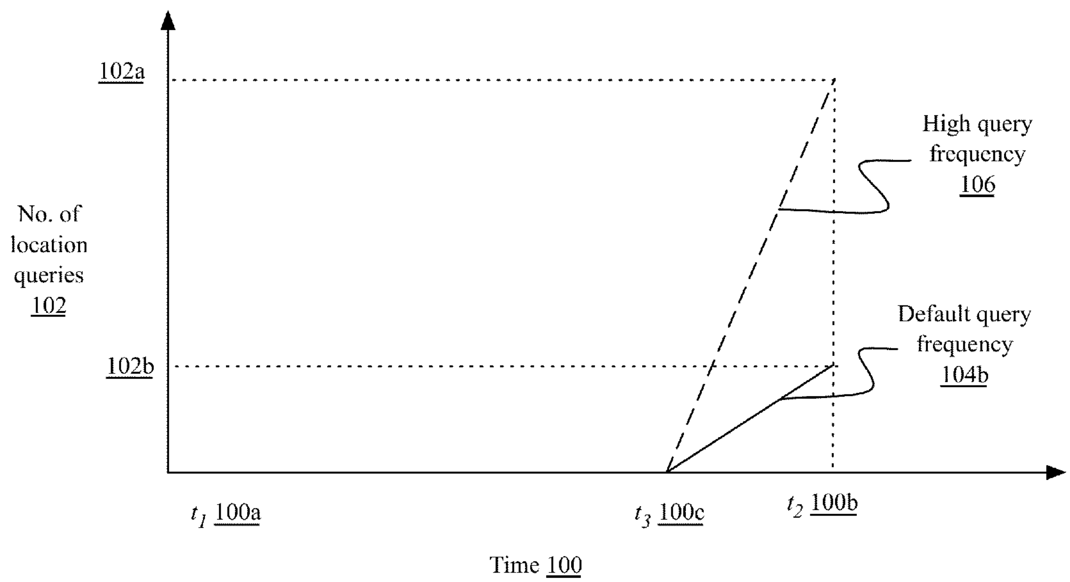

102a
High query frequency 106
No. of location queries 102
102b
Default query frequency 104b
t_1 100a
t_3 100c
t_2 100b
Time 100

FIG. 1B

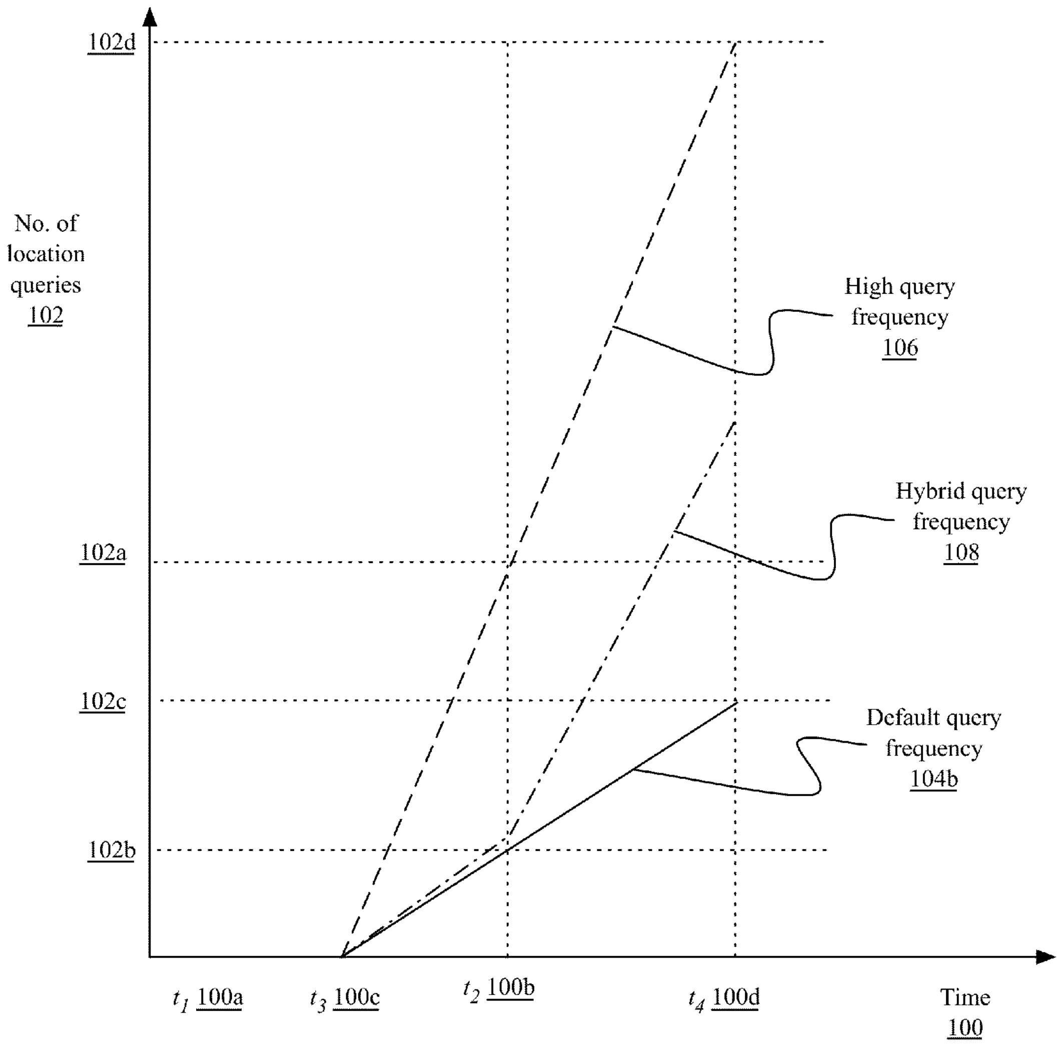

102d
No. of location queries 102
102a
102c
102b
High query frequency 106
Hybrid query frequency 108
Default query frequency 104b
t_1 100a
t_3 100c
t_2 100b
t_4 100d
Time 100

FIG. 1C

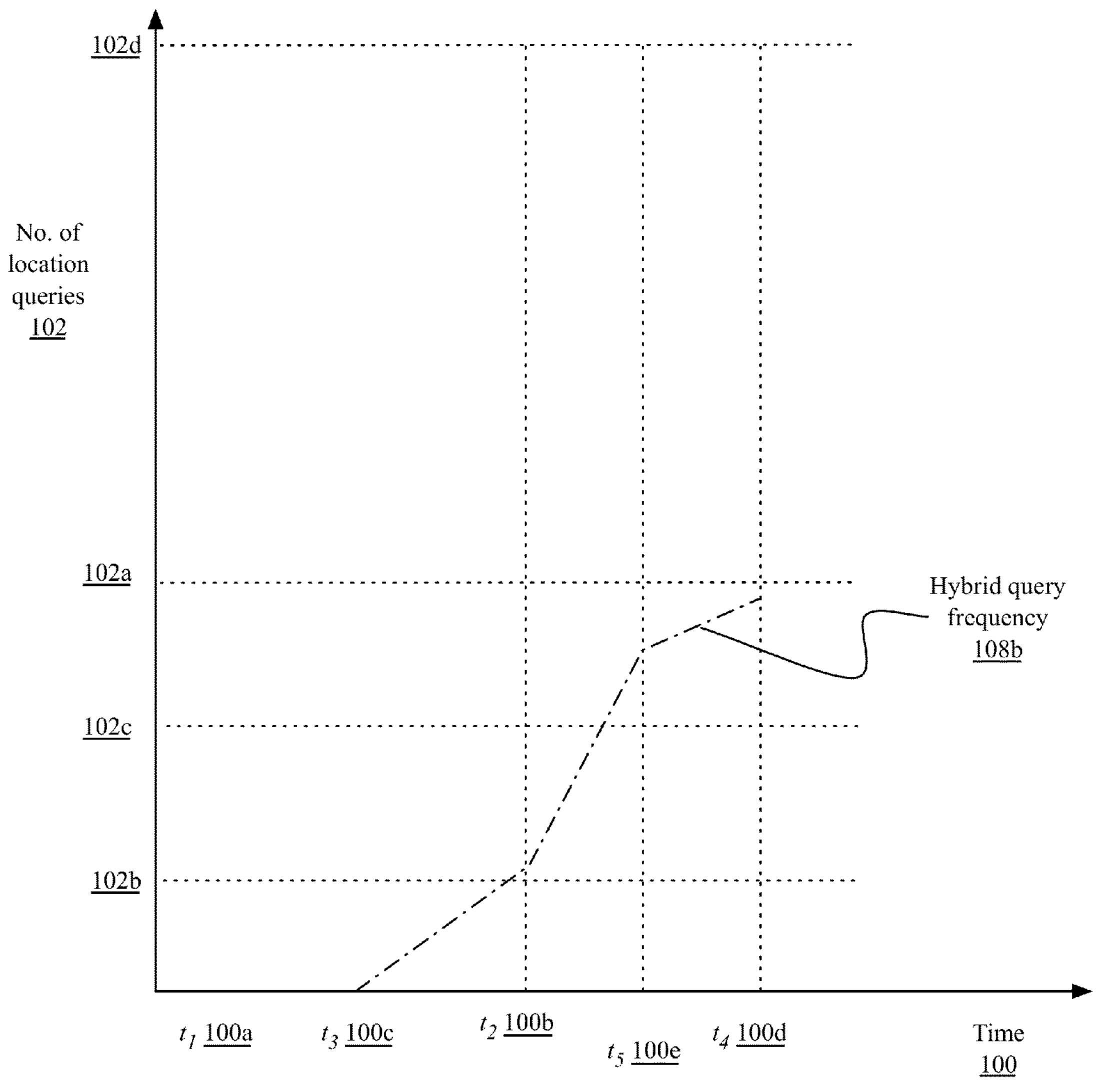

102d
No. of location queries 102
102a
Hybrid query frequency 108b
102c
102b
t_1 100a
t_3 100c
t_2 100b
t_5 100e
t_4 100d
Time 100

FIG. 1D

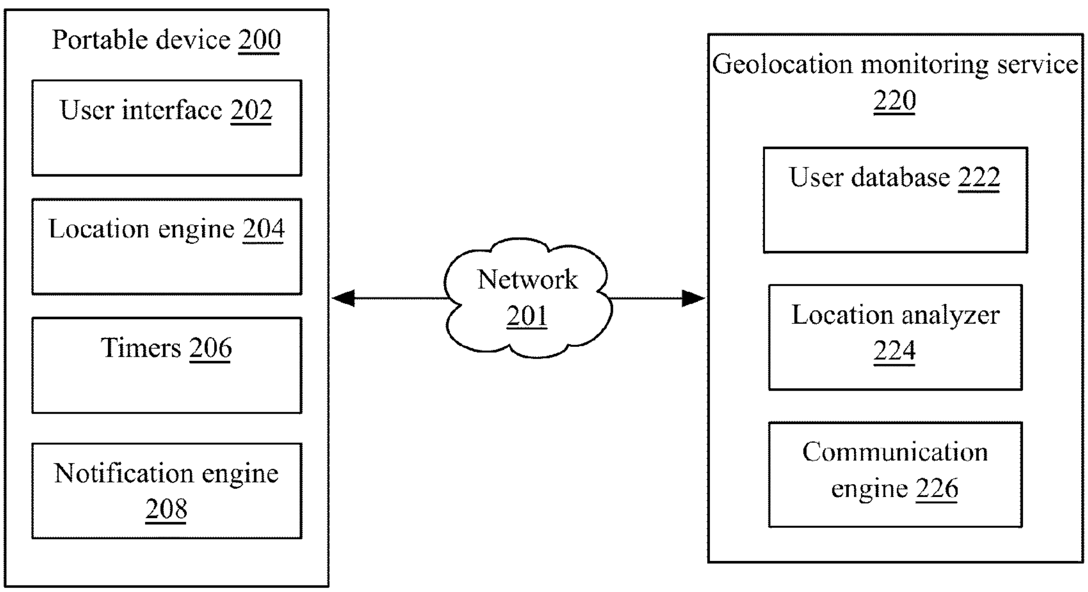
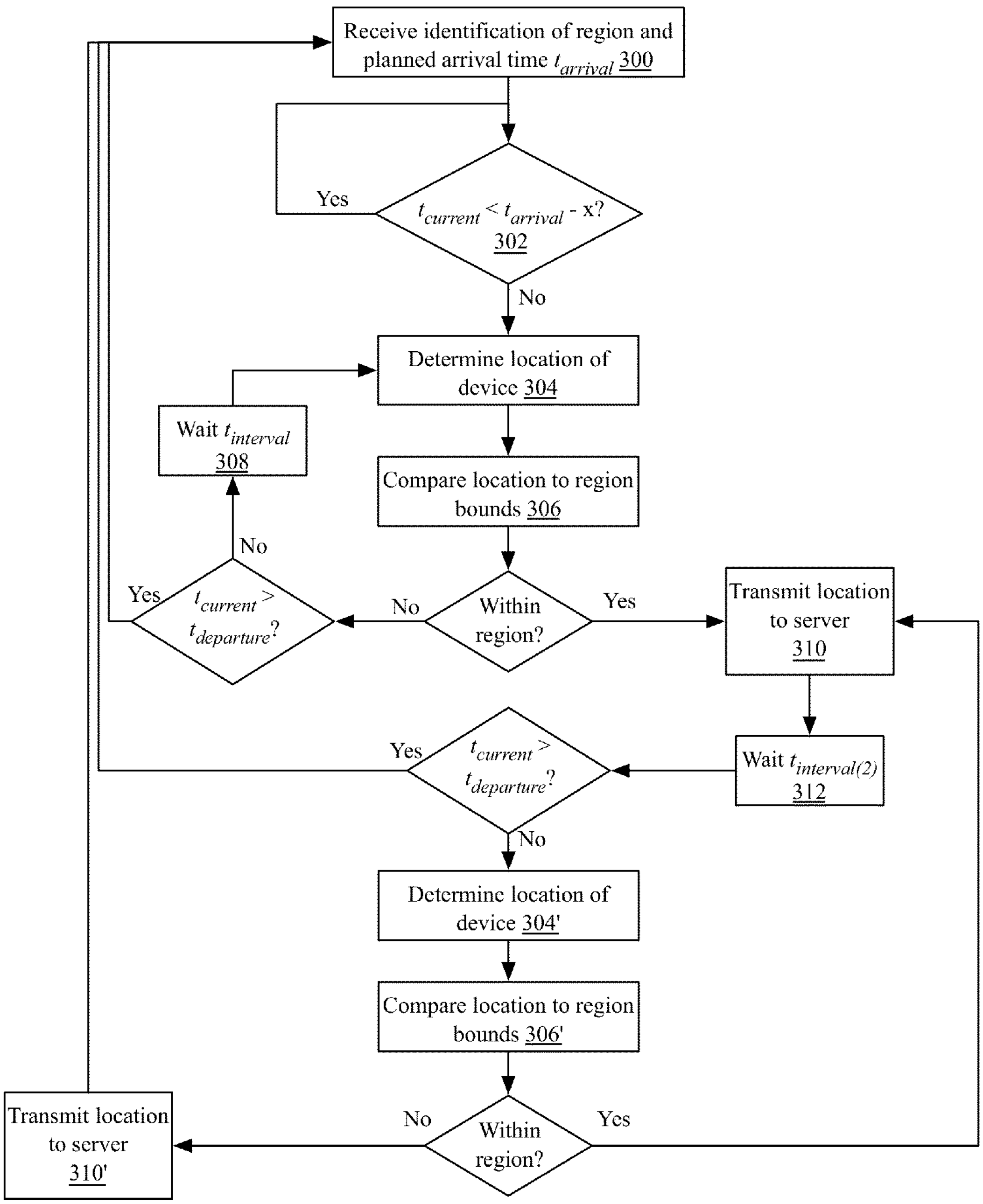

Portable device 200
User interface 202
Location engine 204
Timers 206
Notification engine 208
Network 201
Geolocation monitoring service 220
User database 222
Location analyzer 224
Communication engine 226

FIG. 2



Receive identification of region and planned arrival time $t_{arrival}$ 300
Yes
$t_{current} < t_{arrival} - x$? 302
No
Determine location of device 304
Wait $t_{interval}$ 308
Compare location to region bounds 306
No
Yes
$t_{current} > t_{departure}$?
No
Within region?
Yes
Transmit location to server 310
Yes
$t_{current} > t_{departure}$?
Wait $t_{interval(2)}$ 312
No
Determine location of device 304'
Compare location to region bounds 306'
No
Within region?
Yes
Transmit location to server 310'

FIG. 3

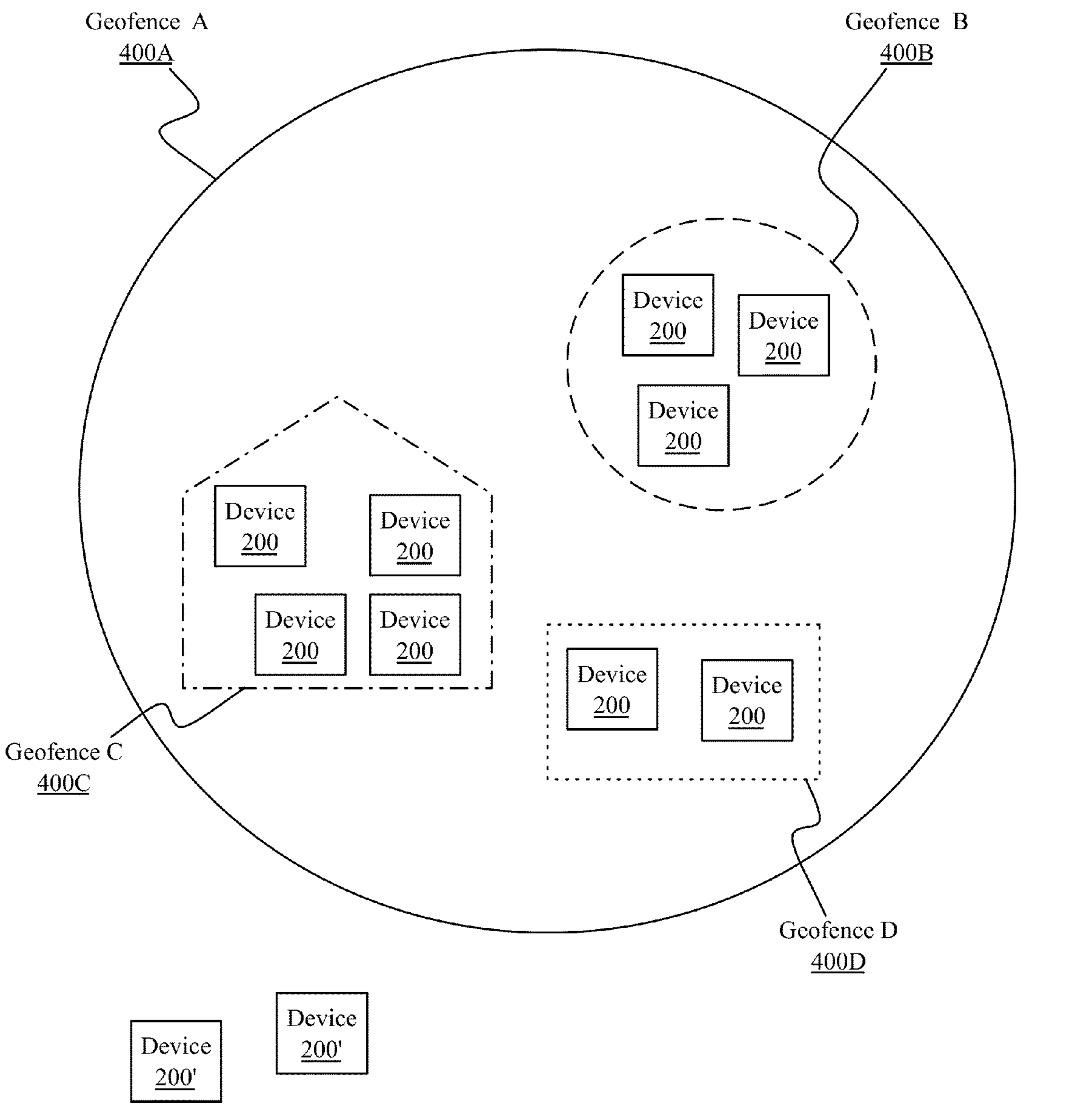

Geofence A
400A
Geofence B
400B
Device
200
Device
200
Device
200
Device
200
Device
200
Device
200
Device
200
Device
200
Device
200
Geofence C
400C
Geofence D
400D
Device
200'
Device
200'

FIG. 4A

Location	Users present	Gender ratio	Average Age
Geofence B 400B	3	2:1	23
Geofence C 400C	4	1:1	32
Geofence D 400D	2	1:0	25

FIG. 4B

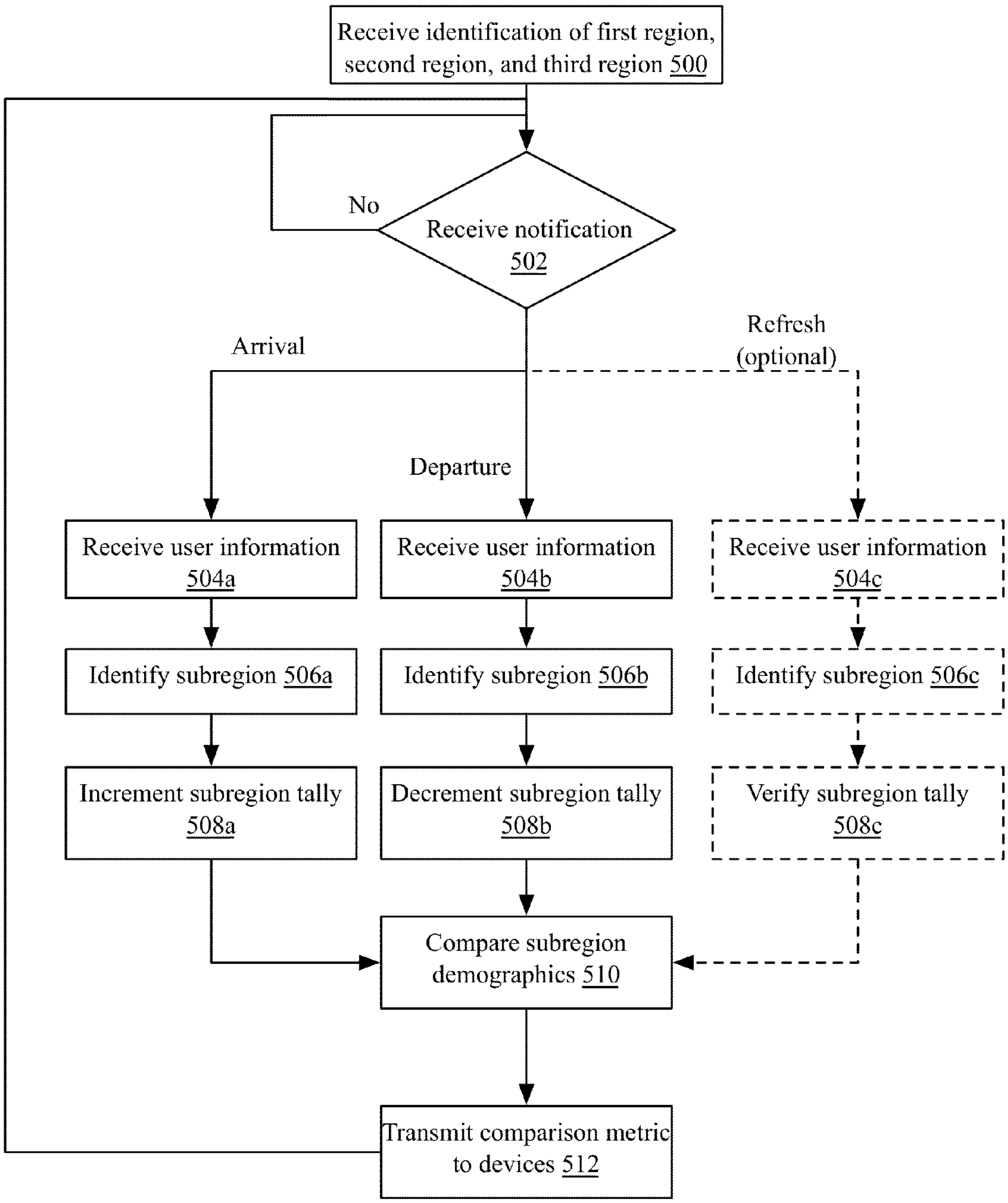

Receive identification of first region, second region, and third region 500
No
Receive notification 502
Arrival
Refresh (optional)
Departure
Receive user information 504a
Receive user information 504b
Receive user information 504c
Identify subregion 506a
Identify subregion 506b
Identify subregion 506c
Increment subregion tally 508a
Decrement subregion tally 508b
Verify subregion tally 508c
Compare subregion demographics 510
Transmit comparison metric to devices 512

FIG. 5

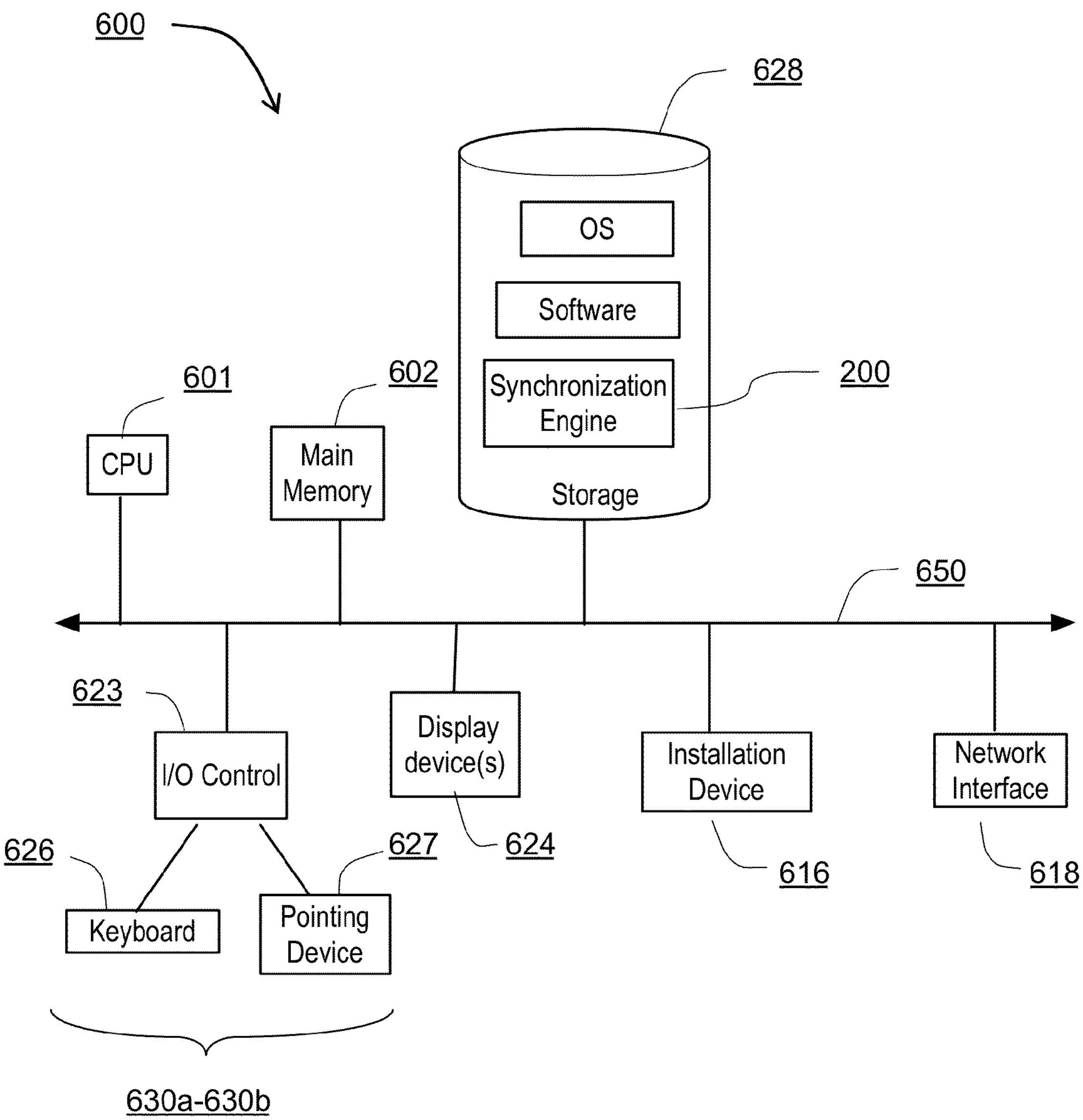

600
628
OS
Software
Synchronization Engine
Storage
200
601
CPU
602
Main Memory
650
623
I/O Control
Display device(s)
Installation Device
Network Interface
626
627
624
616
618
Keyboard
Pointing Device
630a-630b

FIG. 6

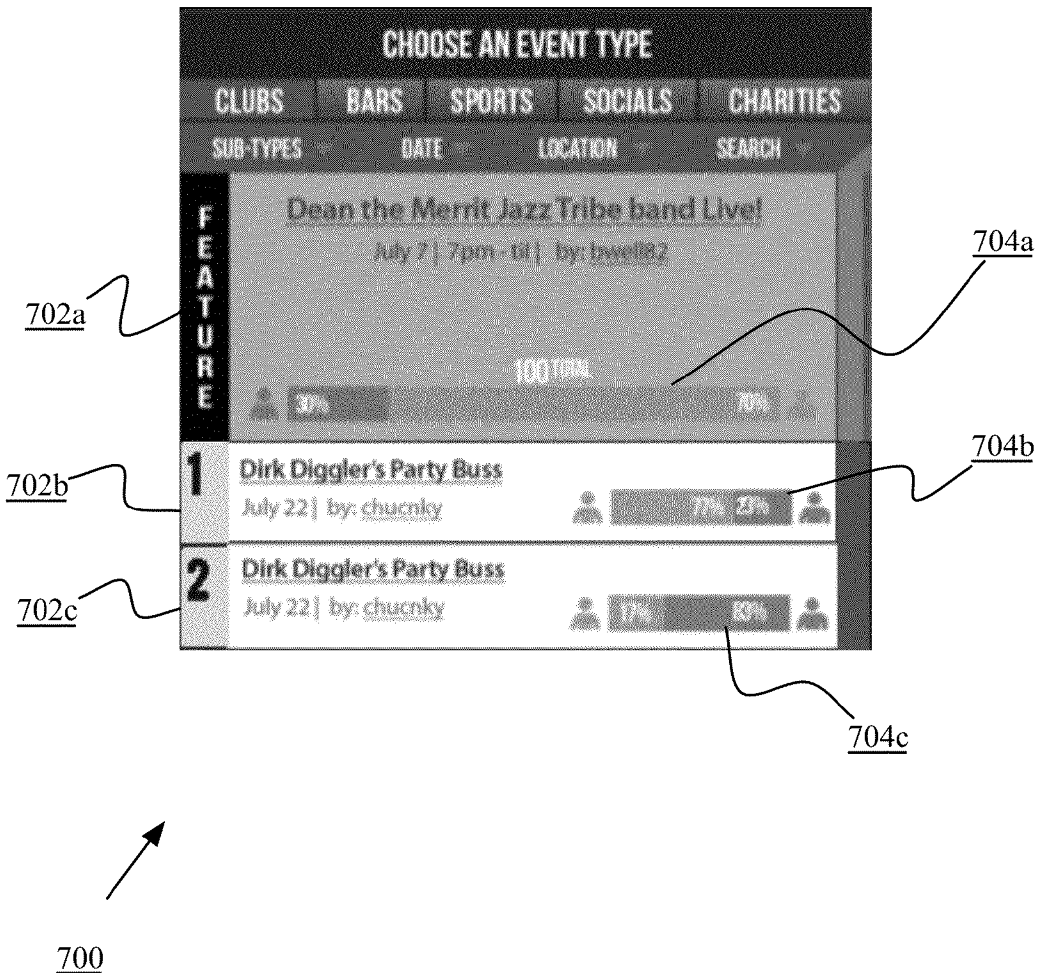
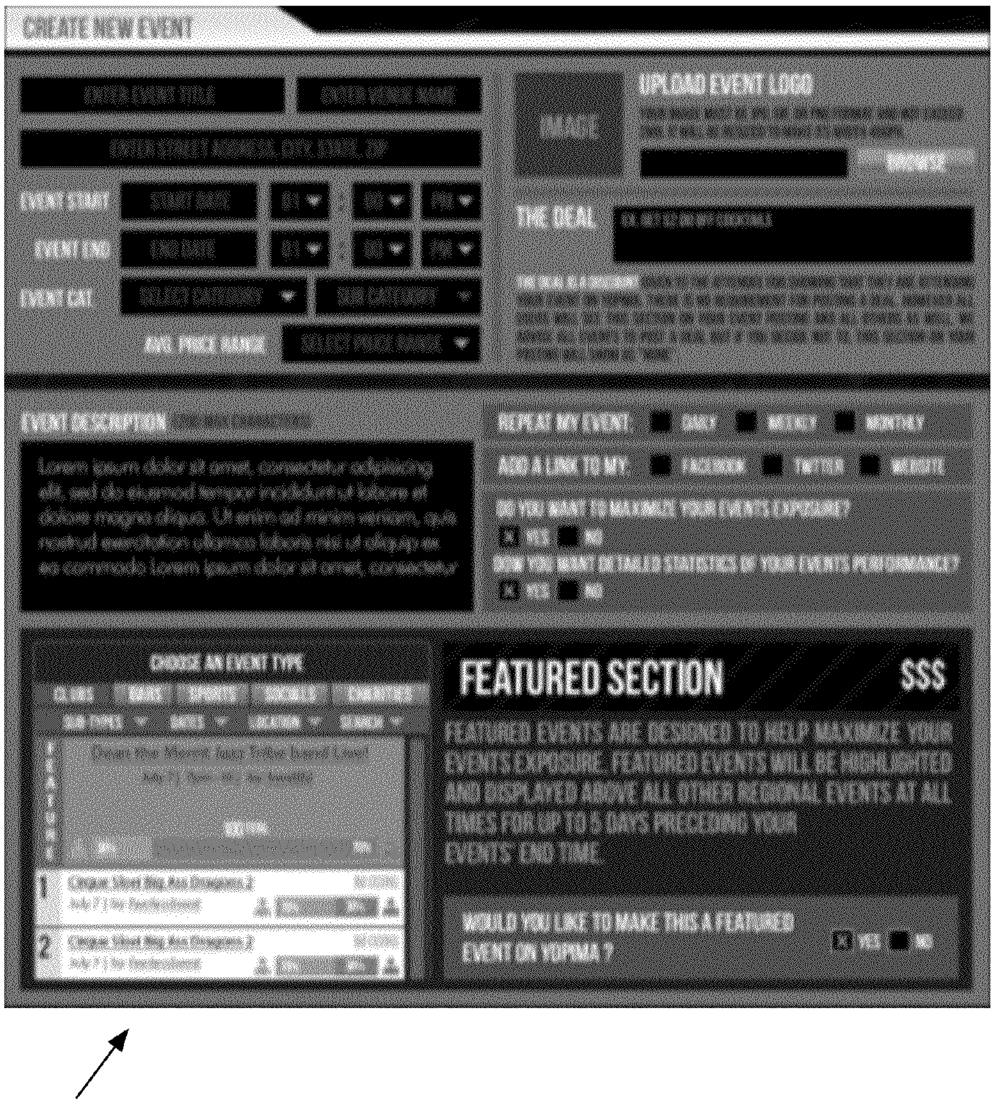
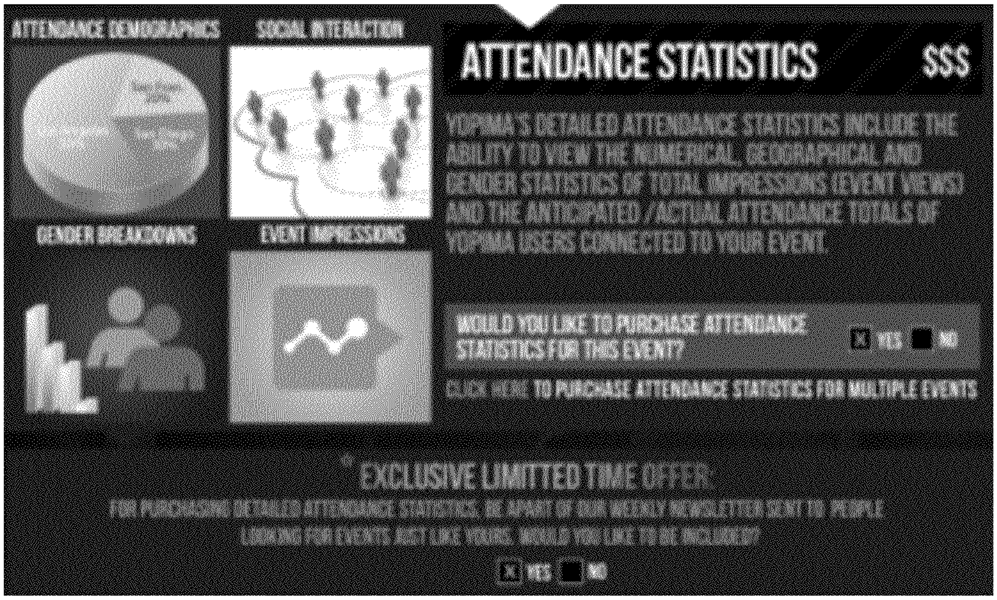

CHOOSE AN EVENT TYPE
CLUBS
BARS
SPORTS
SOCIALS
CHARITIES
SUB-TYPES
DATE
LOCATION
SEARCH
FEATURE
Dean the Merrit Jazz Tribe band Live!
July 7 | 7pm - til | by: bwell82
100 TOTAL
30%
70%
1
Dirk Diggler's Party Buss
July 22 | by: chucnky
77%
23%
2
Dirk Diggler's Party Buss
July 22 | by: chucnky
17%
83%
702a
702b
702c
704a
704b
704c
700

FIG. 7A


CREATE NEW EVENT
ENTER EVENT TITLE
ENTER VENUE NAME
ENTER STREET ADDRESS, CITY, STATE, ZIP
EVENT START
START DATE
EVENT END
END DATE
EVENT CAT
SELECT CATEGORY
SUB CATEGORY
AVG PRICE RANGE
SELECT PRICE RANGE
IMAGE
UPLOAD EVENT LOGO
BROWSE
THE DEAL
EVENT DESCRIPTION
Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo lorem ipsum dolor sit amet, consectetur
REPEAT MY EVENT:
DAILY
WEEKLY
MONTHLY
ADD A LINK TO MY:
FACEBOOK
TWITTER
WEBSITE
DO YOU WANT TO MAXIMIZE YOUR EVENTS EXPOSURE?
YES
NO
YES
NO
CHOOSE AN EVENT TYPE
CLUBS
BARS
SPORTS
SOCIALS
CHARITIES
SUB TYPES
DATES
LOCATION
SEARCH
FEATURED SECTION
$$$
FEATURED EVENTS ARE DESIGNED TO HELP MAXIMIZE YOUR EVENTS EXPOSURE. FEATURED EVENTS WILL BE HIGHLIGHTED AND DISPLAYED ABOVE ALL OTHER REGIONAL EVENTS AT ALL TIMES FOR UP TO 5 DAYS PRECEDING YOUR EVENTS' END TIME.
WOULD YOU LIKE TO MAKE THIS A FEATURED EVENT ON YOPIMA ?
YES
NO

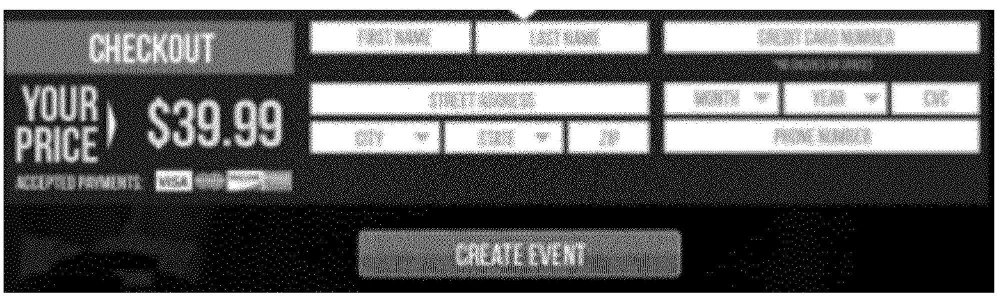
710

FIG. 7B



715

FIG. 7C



720

FIG. 7D

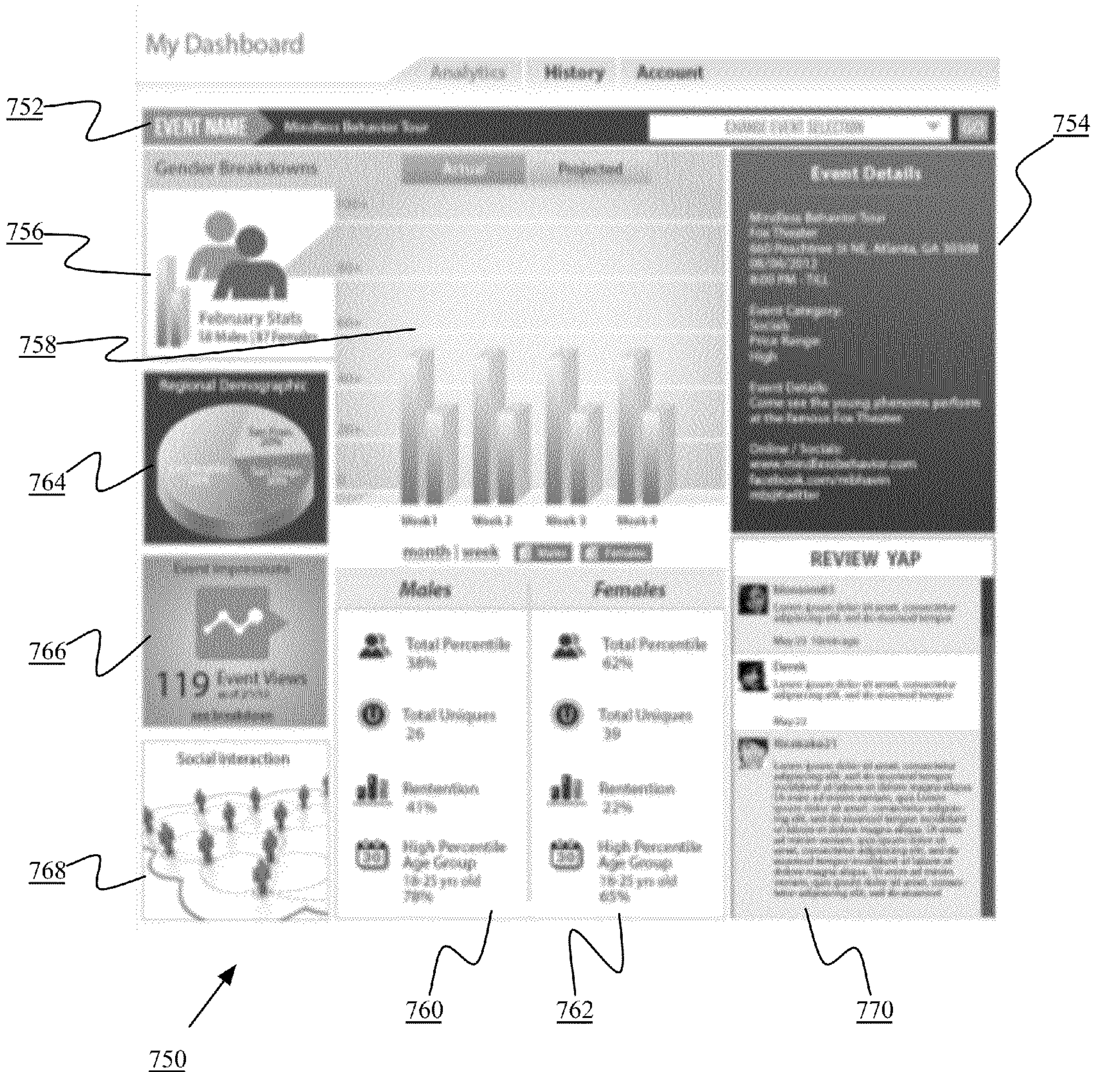

My Dashboard
Analytics
History
Account
EVENT NAME
Gender Breakdowns
Actual
Projected
February Stats
Regional Demographic
Event Details
REVIEW YAP
Males
Females
Total Percentile
Total Uniques
Retention
High Percentile Age Group
119 Event Views
Social Interaction
752
754
756
758
764
766
768
750
760
762
770

FIG. 7E

SYSTEMS AND METHODS FOR COMPARATIVE GEOFENCING

FIELD

The present application relates to systems and methods for geolocation and user tracking. Specifically, the present application relates to tracking locations of a plurality of devices within overlapping geofences and comparing demographics of users of the devices.

BACKGROUND

Many portable electronic or computing devices, such as smart phones, tablets, laptops, or other such devices, include geolocation capabilities or functionality for locating the device (and presumably the user of the device) on a map. Such capabilities may include global positioning system (GPS) receivers, cellular signal receivers, WiFi receivers, etc. In many embodiments, these devices may transmit queries to a location service provider, such as queries including identifiers of cellular or WiFi transmitters that the device can detect and/or signal strengths or timing information. The location service provider may determine, via triangulation, signal databases, or other means, a set of geographic coordinates of the device, and may, in many instances, transmit the coordinates to the device for display on a map or other uses.

SUMMARY

The present disclosure describes systems and methods for time-based geolocation queries, with designated planned arrival and/or departure times or event start/end times. The number of queries can be drastically reduced to reduce battery, bandwidth, and processing requirements; or the rate of queries can be increased within a specified time frame, providing much higher resolution of geolocation information. Geolocation information may be monitored via notifications from portable devices to identify demographics of users within identified regions and subregions, allowing real-time, dynamic comparison of demographic information between locations, such as restaurants, clubs, or events.

In one aspect, the present disclosure is directed to a method for time-based geofencing. The method includes receiving, by a portable computing device, an identification of a region and a planned arrival time. The method also includes identifying, by the portable computing device, that a current time is within a predetermined period of time before the planned arrival time. The method further includes responsive to the identification, determining a current location of the portable computing device. The method also includes comparing the current location of the portable computing device to the identified region. The method further includes repeating the steps of determining the current location of the portable computing device and comparing the current location of the portable computing device to the identified region at a predetermined frequency, responsive to determining that the current location of the portable computing device is outside of the identified region.

In one embodiment, the method includes transmitting, by the portable computing device to a second computing device, an arrival notification, responsive to determining that the current location of the portable computing device is within the identified region. In a further embodiment, the method includes transmitting a user identification to the second computing device. In another further embodiment, the method includes disabling determining a current location of the portable computing device, responsive to determining that the current location of the portable computing device is within the identified region. In yet another further embodiment, the method includes repeating the steps of determining the current location of the portable computing device and comparing the current location of the portable computing device to the identified region at a second predetermined frequency responsive to determining that the current location of the portable computing device is inside of the identified region. In a still further embodiment, the method includes transmitting, by the portable computing device to the second computing device, a departure notification, responsive to determining that the current location of the portable computing device is not within the identified region.

In some embodiments, the method includes disabling determining a current location of the portable computing device, responsive to identifying that a current time is more than a predetermined period of time after the planned arrival time. In other embodiments, the method includes disabling determining a current location of the portable computing device prior to the predetermined period of time before the planned arrival time. In still other embodiments, the method includes transmitting a location query to a location service executed by the second computing device or a third computing device. In yet other embodiments, the method includes transmitting an identification of the current location of the portable computing device to the second computing device or a third computing device; and receiving from said second computing device or third computing device an identification of whether or not the portable computing device is within the identified region.

In another aspect, the present disclosure is directed to a system for time-based geofencing. The system includes a portable computing device, and a clock of a current time maintained by the portable computing device. The portable computing device executes a location engine. The location engine is configured for receiving an identification of a region and a planned arrival time, and identifying that the current time is within a predetermined period of time before the planned arrival time. Responsive to the identification, the location engine determines a current location of the portable computing device, and compares the current location of the portable computing device to the identified region. The location engine is configured for repeating the steps of determining the current location of the portable computing device and comparing the current location of the portable computing device to the identified region at a predetermined frequency, responsive to determining that the current location of the portable computing device is outside of the identified region.

In one embodiment, the location engine is further configured for transmitting, to a second computing device, an arrival notification, responsive to determining that the current location of the portable computing device is within the identified region. In a further embodiment, the location engine is further configured for transmitting a user identification to the second computing device with the arrival notification. In another further embodiment, the location engine is further configured for disabling determining a current location of the portable computing device, responsive to determining that the current location of the portable computing device is within the identified region. In still another further embodiment, the location engine is further configured for repeating the steps of determining the current location of the portable computing device and comparing the current location of the portable computing device to the identified region at a second predetermined frequency responsive to determining that the current location of the portable computing device is inside of the identified

region. In a still further embodiment, the location engine is further configured for transmitting, to the second computing device, a departure notification, responsive to determining that the current location of the portable computing device is not within the identified region.

In some embodiments, the location engine is further configured for disabling determining a current location of the portable computing device, responsive to identifying that a current time is more than a predetermined period of time after the planned arrival time. In other embodiments, the location engine is further configured for disabling determining a current location of the portable computing device prior to the predetermined period of time before the planned arrival time. In yet other embodiments, the location engine is further configured for determining a current location of the portable computing device by transmitting a location query to a location service executed by the second computing device or a third computing device. In still yet other embodiments, the location engine is further configured for comparing the current location of the portable computing device to the identified region by transmitting an identification of the current location of the portable computing device to the second computing device or a third computing device, and receiving from said second computing device or third computing device an identification of whether or not the portable computing device is within the identified region.

In another aspect, the present disclosure is directed to a method for tracking locations of a plurality of devices within overlapping geofences. The method includes receiving, by a location analyzer executed by a computing device, an identification of (i) a first region defined by a first geofence; (ii) a second region defined by a second geofence distinct from the first geofence; and (iii) a third region defined by a third geofence including the first region and second region. The method also includes receiving, by the location analyzer, a plurality of arrival notifications from a corresponding plurality of devices, each arrival notification sent by each device responsive to said device determining it has entered the third geofence. The method further includes receiving, by the location analyzer, user information for a user of each of the plurality of devices. The method also includes identifying, by the location analyzer, a first subset of the plurality of devices that are within the first region and a second subset of the plurality of devices that are within the second region. The method further includes comparing, by the location analyzer, user information of the users of the first subset of the plurality of devices and user information of the users of the second subset of the plurality of devices. The method also includes transmitting, by the location analyzer to a second computing device, a comparison metric identifying a difference between users of the first subset of the plurality of devices and users of the second subset of the plurality of devices.

In one embodiment of the method, the first region and the second region do not overlap. In another embodiment of the method, each arrival notification is sent by each device further responsive to a current time being within a predetermined time period of a planned arrival time.

In some embodiments, each arrival notification comprises a geographic location of the corresponding device. In other embodiments, the method includes receiving, by the location analyzer, one or more current device locations from a corresponding one or more of the plurality of devices, sent by each device responsive to said device determining it is still within the third geofence. In a further embodiment, the method includes re-identifying a first subset of the plurality of devices that are within the first region and a second subset of the plurality of devices that are within the second region based on the received one or more current device locations. The method also includes re-comparing, by the location analyzer, user information of the users of the first subset of the plurality of devices and user information of the users of the second subset of the plurality of devices. The method further includes transmitting, by the location analyzer to the second computing device, an updated comparison metric identifying a change in the difference between users of the first subset of the plurality of devices and users of the second subset of the plurality of devices.

In still another aspect, the present disclosure is directed to a system for tracking locations of a plurality of devices within overlapping geofences. The system includes a computing device comprising a processor executing a location analyzer. The location analyzer is configured for receiving an identification of (i) a first region defined by a first geofence; (ii) a second region defined by a second geofence distinct from the first geofence; and (iii) a third region defined by a third geofence including the first region and second region. The location analyzer is also configured for receiving a plurality of arrival notifications from a corresponding plurality of devices, each arrival notification sent by each device responsive to said device determining it has entered the third geofence. The location analyzer is further configured for receiving user information for a user of each of the plurality of devices, and for identifying a first subset of the plurality of devices that are within the first region and a second subset of the plurality of devices that are within the second region. The location analyzer is also configured for comparing user information of the users of the first subset of the plurality of devices and user information of the users of the second subset of the plurality of devices. The location analyzer is further configured for transmitting, to a second computing device, a comparison metric identifying a difference between users of the first subset of the plurality of devices and users of the second subset of the plurality of devices.

In one embodiment of the system, the first region and the second region do not overlap. In another embodiment of the system, each arrival notification is sent by each device further responsive to a current time being within a predetermined time period of a planned arrival time. In still another embodiment of the system, each arrival notification comprises a geographic location of the corresponding device.

In some embodiments, the location analyzer is further configured for receiving one or more current device locations from a corresponding one or more of the plurality of devices, sent by each device responsive to said device determining it is still within the third geofence. In a further embodiment, the location analyzer is further configured for re-identifying a first subset of the plurality of devices that are within the first region and a second subset of the plurality of devices that are within the second region based on the received one or more current device locations. The location analyzer is also configured for re-comparing user information of the users of the first subset of the plurality of devices and user information of the users of the second subset of the plurality of devices. The location analyzer is further configured for transmitting, to the second computing device, an updated comparison metric identifying a change in the difference between users of the first subset of the plurality of devices and users of the second subset of the plurality of devices.

In yet another aspect, the present disclosure is directed to a method for tracking locations of a plurality of devices within overlapping geofences. The method includes receiving, by a portable computing device, an identification of a first geofence defining a first region. The method also includes determining a current location of the portable computing

device. The method further includes comparing the current location of the portable computing device to the identified first geofence. The method also includes transmitting, by the portable computing device to a second computing device, an arrival notification, responsive to determining that the current location of the portable computing device is within the identified first region, the arrival notification including an identification of the current location of the portable computing device within one of a plurality of subregions of the first region defined by a corresponding plurality of geofences.

In one embodiment, the method includes receiving, by the portable computing device from the second computing device, an identification of one or more users of other portable computing devices within the same one of the plurality of subregions of the first region as the portable computing device. In a further embodiment, the identification of the one or more users of other portable computing devices comprises an identification of a gender ratio of the one or more users within the same one of the plurality of subregions.

In some embodiments, the method includes transmitting a current location of the portable computing device to the second computing device, at a predetermined frequency, until the portable computing device determines that the current location of the portable computing device is no longer within the identified first region. In another embodiment, the method includes transmitting a current location of the portable computing device to the second computing device, at a predetermined frequency, until expiration of a predetermined time period. In yet another embodiment, the method includes receiving, by the portable computing device, an identification of a planned arrival time. The method also includes identifying, by the portable computing device, that a current time is within a predetermined period of time before the planned arrival time. In such embodiments, determining a current location of the portable computing device is performed responsive to the identification that the current time is within the predetermined time period before the planned arrival time. In a further embodiment, the method includes, prior to transmitting the arrival notification, repeating determining the current location of the portable computing device and comparing the current location of the portable computing device to the identified first geofence at a predetermined frequency, responsive to determining that the current location of the portable computing device is outside of the identified first region. In many embodiments, the arrival notification includes an identification of a user of the portable computing device.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1**A is a chart illustrating a number of location queries over time at a default query frequency in one embodiment of a geolocation system;

FIG. **1**B is a chart illustrating a number of location queries over time in embodiments of a geolocation system with a planned arrival time, including a default query frequency and a high query frequency;

FIG. **1**C is another chart illustrating a number of location queries over time in embodiments of a geolocation system with a planned arrival time and departure time, including a default query frequency and a high query frequency;

FIG. **1**D is still another chart illustrating a number of location queries over time in embodiments of a geolocation system with a planned arrival time and departure time, including a default query frequency and a high query frequency;

FIG. **2** is a block diagram of an embodiment of a system for geolocation and user demographics monitoring;

FIG. **3** is a flow chart of an embodiment of a method for time-based geolocation;

FIG. **4**A is a diagram of an embodiment of comparative geofences;

FIG. **4**B is a exemplary table of an embodiment of demographics comparison for comparative geofences;

FIG. **5** is a flow chart of an embodiment of a method for comparative geofencing and demographics tracking;

FIG. **6** is a block diagram of an exemplary computing device useful for practicing the methods and systems described herein; and

FIGS. **7**A-**7**E are exemplary screenshots of an embodiment of a user interface for defining events and reviewing tracked demographics.

In the drawings, like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements.

DETAILED DESCRIPTION

The following description in conjunction with the above-reference drawings sets forth a variety of embodiments for exemplary purposes, which are in no way intended to limit the scope of the described methods or systems. Those having skill in the relevant art can modify the described methods and systems in various ways without departing from the broadest scope of the described methods and systems. Thus, the scope of the methods and systems described herein should not be limited by any of the exemplary embodiments and should be defined in accordance with the accompanying claims and their equivalents.

For purposes of reading the description of the various embodiments below, the following descriptions of the sections of the specification and their respective contents may be helpful:

Section A describes embodiments of methods and systems for time-based geolocation;

Section B describes embodiments of methods and systems for comparative geofencing;

Section C describes embodiments of computing devices which may be useful for practicing embodiments described herein; and

Section D describes an exemplary user interface for setting up time-based geolocation events and reviewing comparative geofence demographics.

A. Embodiments of Methods and Systems for Time-Based Geolocation

Although useful, geolocation systems tend to consume a great deal of resources of portable computing devices. For example, the devices may expend battery power increasing signal gain for GPS antennas or WiFi antennas, may utilize many CPU cycles during processing of location information, transmit frequent requests to a location service provider, etc. This problem is compounded with modern uses of geofencing. Geofences define geographic locations, and may comprise circles, squares, paths, or any other 2-dimensional, or in some embodiments, 3-dimensional shape. Geofences are typically used for triggering an event, such as the location-based reminders provided by the iOS operating system component Siri, manufactured by Apple Inc. of Cupertino, Calif. For example, in one such embodiment, a user may set a location based reminder to remind them to "feed the cats" when they arrive "home", which may be defined as a short radius (e.g. 10 m) circular geofence centered on a geographic coordinate previously designated as "home". The user's

device may periodically transmit location queries to a service provider, receive coordinates, and determine whether the device is within the circle. Upon determining that the device is within the geofenced region, the device may trigger the event or reminder, such as playing a sound or displaying a message.

In these typical systems, the user's device may transmit location queries and perform coordinate comparisons at frequent intervals, regardless of how far the user is from arriving home and regardless of whether the user has even departed a previous location. Rather, the device begins performing location comparisons as soon as the user sets the trigger. As these notification and location services may run in the background, the device may perform queries without the user realizing it for days, weeks, or even months if the geofence is not entered, reducing battery life, and needlessly consuming bandwidth and CPU cycles. Even if the user does arrive at home and triggers the event, if there are further location based reminders set for other locations, the device will continue performing queries.

For example, referring now to FIG. **1**A, illustrated is a chart showing a number of location queries **102** over time **100** at a default query frequency **104***a* in one embodiment of a geolocation system. As shown, at some time t_1 **100***a*, a user may set a location based event, notification, or reminder. In response to setting the event, the device will determine parameter, transmit queries, and perform geographic location comparisons at the default query frequency, such as once every 15 minutes. At some subsequent time t_2 **100***b*, the user may arrive at the location. On a subsequent query and comparison, the device may identify that it is within the geofenced area, and may trigger the event or notification. At this point, the device will have made a number of location queries **102***a* equal to t_2-t_1 divided by the query frequency. For example, if it was 12 hours between when the user set the event and when the user arrived at the designated region, and the frequency was one query every 15 minutes, the device would have transmitted 48 queries. If the user had not planned on leaving their previous location for the first 11 hours, 44 of those queries would have been unnecessary.

Accordingly, the systems and methods described herein allow for time-based geolocation queries, with designated planned arrival and/or departure times or event start/end times. The number of queries can be drastically reduced, or the rate of queries can be increased within a specified time frame, providing much higher resolution of geolocation information.

For example, referring now to FIG. **1**B, illustrated is another chart showing a number of location queries **102** over time **100** in embodiments of a geolocation system with a planned arrival time. As with the example above, the user may set a location based event, notification, or reminder at a first time t_1 **100***a*, but may specify a planned arrival time. In some embodiments, the planned arrival time may be an actual estimated time of arrival, such as t_2 **100***b*. The system may select a prior time t_3 **100***c* to begin initiating queries, according to a policy. For example, a policy may indicate that the device should begin initiating location queries one hour prior to a planned arrival time t_2 **100***b*, half an hour, or any other such predetermined period of time. In other embodiments, the user may set the planned arrival time t_3 **100***c* directly as a period of time before the event start or likely actual arrival time.

At t_3 **100***c*, the device may begin identifying parameters and transmitting location queries. In some embodiments, the device may initiate queries at the a default query frequency **104***b* as discussed above, such as a 15 minute interval. If the planned arrival time t_3 was one hour prior to the user arriving at the geofence, then this would result in only 4 queries **102***b*, utilizing less than 10% of the resources required in the example of FIG. **1**A. In other embodiments, the device may initiate queries at a higher query frequency **106**, such as once every 75 seconds. As shown, in such an embodiment, the device may transmit the same number of queries **102***a* as in the example of FIG. **1**A, but only during the time during which the user is likely to be arriving at the geofence.

Increasing the query frequency may reduce arrival time errors: if the user arrives at the geofence shortly after a query has been transmitted, the device may need to wait for almost the entire query interval before transmitting another query and identifying that the user has reached the geofence, or up to 15 minutes in the example of FIG. **1**A, but only up to 75 seconds in the high query frequency example of FIG. **1**B.

Furthermore, in some embodiments, the device may continue transmitting geolocation queries while the user is within the geofence, until the user leaves or a predetermined departure time or event end time arrives. For example, rather than just being used for reminders that are only activated upon arrival at a location, the geolocation services may be used for identifying a location within a geofence during an event, transmitting notifications that a user is at an event, coordinating meetings between multiple users within a geofenced region, and/or triggering events upon departure from a geofenced region.

For example, FIG. **1**C is another chart illustrating a number of location queries over time in embodiments of a geolocation system with a planned arrival time and departure time or start time and end time. As shown and as discussed above in connection with FIG. **1**C, in some embodiments, a device may begin initiating queries at a predetermined time period t_3 **100***c* before a planned arrival time t_2 **100***b* or actual arrival time. Once the user arrives at the geofenced region at time t_2 **100***b*, the device may continue initiating geolocation queries until a planned departure time t_4 **100***d*. For example, if the event is a party lasting two hours, the device may continue transmitting queries at the default query frequency **104***b* as discussed above resulting in 8 additional queries or a total of 12 queries **102***c*. In other embodiments, the device may continue transmitting queries at the high query frequency **106**, resulting in 144 queries total. In other embodiments using a hybrid query frequency **108**, the device may transmit queries at a first query frequency, such as once every 15 minutes, until the user arrives at the geofenced region, and then may transmit queries at a second higher query frequency, such as once every minute.

Although these latter embodiments consume more resources, increasing the query frequency during the event may allow for finer resolution of location within a space. For example, in implementations of location tracking in large nightclubs, a user's location may be tracked as they walk around, allowing monitoring by venue operators of the number of users on a dance floor, at a particular bar or lounge, or waiting for a coat check.

In another similar hybrid query frequency embodiment not illustrated, the device may transmit queries at a high rate until the user arrives at a geofenced region, and then transmit queries at a reduced rate until the user leaves the region or the planned departure or end time occurs. This may be useful in implementations in which an event needs to be coordinated precisely with a user's arrival, such as beginning cooking of a dish at a restaurant, but where less accurate tracking is required for a departure time.

In a further hybrid query frequency embodiment, a location service provider may transmit a query frequency to a device, such as with a response to a query. For example, the query

frequency for the device to use may be placed in a header or options field of a data packet. This may allow the location service provider to dynamically adjust query frequencies based on latency or processing requirements, or responsive to some external event. For example, in the event of a fire or other emergency, an operator of a venue with an associated geofence may direct a location service provider to command all devices within the geofenced region to initiate queries at a high query frequency, allowing the operator to quickly identify whether any users are still in the venue.

In still other embodiments, rather than ending queries upon departure from a geofenced region or venue, a device may transmit queries at a third frequency responsive to the user departing the region prior to a planned departure time or event end time t_4 **100***d*. For example, as shown in the chart of FIG. **1**D, a device may begin initiating queries at a predetermined time period t_3 **100***c* before a planned arrival time t_2 **100***b* or actual arrival time. Once the user arrives at the geofenced region at time t_2 **100***b*, the device may transmit queries at an increased frequency. Upon detecting that the user has left the geofenced region at time t_5 **100***e*, the device may continue initiating geolocation queries at a third, lower frequency until a planned departure time t_4 **100***d*. This may be useful in implementations where the user may return to the geofenced region prior to the planned end time of the event.

In many embodiments, the device may transmit a notification to a second device, such as a server operated by a venue operator. The notification may include any type and form of relevant information, including a device identifier, user identifier, user profile, user demographic information such as gender or age, and/or geographic coordinates. In some embodiments, the second device may include or communicate with a database of users, such that the device only needs to send a user identifier (and possibly coordinates) and the second device may retrieve a stored user profile to identify demographic information about the user. The notification may be transmitted via any means, including text or SMS message, email, or data packet, such as an HTTP POST request, JSON query, or other means. The notifications may be sent on arrival at a geofenced area, upon departure from the area, and/or periodically while the device is within the geofenced area.

Referring now to FIG. **2**, illustrated is a block diagram of an embodiment of a system for geolocation and user demographics monitoring. As shown, a portable device **200**, such as a tablet, smart phone, or other computing device, may communicate via a network **201** with a geolocation monitoring service **200**, which may be executed by another device, such as a server, workstation, desktop computing device, server farm, or a virtual machine or cloud service executed by a computing device or farm of computing devices. The network **201** may comprise any type and form of network, including a wide area network such as the Internet, and may comprise one or more types of physical networks, including cellular networks, WiFi networks, and wired networks. For example, in many common implementations, the portable device **200** may communicate with a cellular network such as a 3 G or 4 G network, which may connect via one or more gateways to a wide area network such as the Internet. In other embodiments, the portable device **200** may communicate with the geolocation monitoring service **220** via a local area network, wireless local area network, near-field communication ad-hoc network or similar network, or any other type and form of communication interface.

In some embodiments, the portable device **200** may include a user interface **202**. User interface **202** may comprise any type and form of user interface, including a graphical user

interface and/or command line interface, for setting a time-based geolocation notification event. In some embodiments, a user may set a time-based geolocation notification by indicating that they will be at an event or venue at a specified time. For example, the user may indicate that they will be attending a nightclub at a particular date and time, or will be attending a concert at a particular venue on a specified day and time. The device may set a time-based geolocation event accordingly. In one such embodiments, the user may make such indications in connection with purchasing tickets to or registering for an event, pre-paying an entry fee, purchasing a VIP service or bottle service, watching an advertisement, or any other such processes. In many embodiments, the user interface **202** may be provided by a web browser, while in other embodiments, the user interface **202** may be provided by a dedicated application, such as a smartphone application. Such applications may incorporate other desirable features, including posting messages to a social network service, or geotagging photos or videos or tagging media as being associated with an event the user is attending.

The device **200** may include a location engine **204**. Location engine **204** may comprise an application, service, server, daemon, routine, library, or any type and form of executable logic for location determination and comparison. In many embodiments, location engine **204** may be provided by an operating system of device **200**, and may communicate with user interface **202**, timers **206**, and/or notification engine **208** via an application programming interface (API) or other method. Location engine **204** may comprise functionality for receiving, amplifying, or otherwise processing signals such as those from GPS satellites, cellular transmitters, and/or WiFi transmitters. In some embodiments, location engine **204** may directly provide geographic coordinates to the user interface **202** and/or notification engine **208**, such as from a GPS reception and processing algorithm, while in other embodiments, location engine **204** may transmit a query to a location service provider including identifiers and strengths of visible cellular towers, WiFi service set identifier (SSID) names, IP addresses, or device identifiers. Location engine **204** may, alone or in combination with a location service provider, perform GSM location or triangulation, time difference of arrival (TDOA) processing, near location based service (NLBS) tracking, or any other location determination system.

In many embodiments, location engine **204** may also perform comparisons of location coordinates of the device, either internally determined or received from a location service provider, with geofence coordinates. As discussed above, geofences may be of any shape or size and may be defined by geographic boundaries or paths. Location engine **204** may perform mathematical comparisons of coordinates of the device to the geofence identifying coordinates to determine whether the device is within the geofence or not. For example, in one embodiment, a geofence may be defined by a center coordinate and a radius, and the location engine may determine whether a distance between the center coordinate and coordinates of the device exceed the length of the radius. Other algorithms may be used, such as comparing device coordinates to a bitmap or array of geofence coordinates or to geofence coordinates determined based on a union of several Boolean conditions, for complex geofence shapes.

Portable device **200** may execute or maintain one or more timers **206**, which may also include a local or absolute time clock. Clocks or timers **206** may be provided by an operating system of the device, or may be maintained separately by notification engine **208** and/or location engine **204**. Timers **206** may be periodic, such as query interval timers, or may be

clock alarms or set times, such as planned arrival and departure times or start and end times for an event. As discussed above, periodic timers **206** may be variable in length or set according to a policy or received command.

Portable device **200** may comprise a notification engine **208**, which may be an application, service, server, daemon, routine, or other executable logic for transmitting one or more notifications to a geolocation monitoring service **220** or other computing device. Notification engine **208** may comprise a portion of a network stack, or may communicate with a network stack or other communications interfaces. For example, notification engine **208** may generate data packets for transmission by a cellular transmitter of the device **200**. Notifications may be of any type and form, including text messages, SMS messages, MMS messages, or any type and form of data packets. For example, in some embodiments, notifications may comprise representational state transfer (REST) requests, such as HTTP POST or parameterized GET requests, XML data, or any other type and form of transmission. In many embodiments, notifications may be asynchronous, or not require confirmation. For example, notifications may be sent via a user datagram protocol (UDP) or other unreliable protocol, or may be transmitted via a reliable protocol such as transmission control protocol (TCP) with responses ignored or not expected.

As discussed above, notifications may be sent by the device responsive to arrival at a geofenced region, responsive to departure from the region, and/or periodically while within the geofenced region. Notifications may include user identification, device identification, user profile information, user demographic information such as age or gender, a user image or picture, coordinates of the device, or any other type and form of information. In one embodiment, to reduce bandwidth requirements, the device may transmit a first set of data with an initial notification, and a subset of the data with later notifications. For example, the device may transmit some or all of the above-identified information with a first notification, and only a user identification and/or coordinates in a subsequent notification. In a related embodiment, the device may receive a notification identifier from the geolocation monitoring service responsive to the first notification, such as a small temporary identifier, and may simply retransmit the identifier and coordinates in further notifications until the user leaves the geofenced region or the event end time occurs. In another embodiment, the device may transmit a portion of available information with each notification, providing the full set of information over the course of several notifications.

In still other embodiments, the user may pre-register with the geolocation monitoring service, such that by sending a user identifier, the monitoring service may retrieve a user profile or demographic information. For example, as discussed above in connection with user interface **202**, the user may log into an application or web site to indicate that they will attend an event, purchase tickets to the event, or otherwise generate the time-based geolocation event. The web site may be provided by a web server of geolocation monitoring service **220** or in communication with geolocation monitoring service **220**, or the application executed on the device **200** may communicate with the geolocation monitoring service **220** when the user registers for the event or purchases tickets. When the user first registers with the web site or application, the user may fill out a profile or link to a social networking profile, such as a Facebook account provided by Facebook, Inc. of Menlo Park, Calif., or a Google Plus account provided by Google, Inc. of Mountain View, Calif. The profile may be associated with a user identifier, such that the monitoring service may retrieve the profile and identify demographic

information about the user responsive to receiving the notification including the user identifier.

Geolocation monitoring service **220** may include or maintain a user database **222**, or communicate with a social network provider to retrieve user profiles, as discussed above. User database **222** may comprise a database, flat file, data file, SQL database, or any other type and form of data storing information about users, including names, identifiers, device identifiers, demographic information such as age or gender, past event attendance information, purchase history, credit card or other purchase information, associations or connections with other users, photos or other multimedia, or any other type and form of information. In some embodiments, user database **222** may be populated by users filling out profiles during registration with the service, while in other embodiments, user database **222** may be populated by retrieval of data from a social networking service.

Geolocation monitoring service **220** may comprise a location analyzer **224**. Location analyzer **224** may comprise an application, service, server, daemon, routine, or other executable logic for receiving notifications from a plurality of devices **200** of users, identifying devices as being within one or more geofenced regions or overlapping regions, and determining aggregated demographic information for a location. For example, location analyzer **224** may receive arrival notifications from a plurality of devices in a geofenced region, such as a nightclub; may retrieve gender demographic information from corresponding user profiles; and may identify a gender ratio of users in the geofenced region. Said gender ratio may be displayed on a website or other service, transmitted to devices **200** for display in a web browser or other application, or otherwise shown to potential visitors of the nightclub. This may allow dynamic, real-time display and comparison of demographic information between a plurality of venues, allowing potential visitors to select venues based on desired gender ratios. Similarly, average ages or age ranges may be displayed, as well as any other demographic criteria.

Demographic criteria may also be provided to the operator of each venue, allowing them to dynamically adjust offers based on attendance, such as reducing entry admission for an underrepresented gender, or dynamically changing music selections to accommodate the majority of patrons' preferences (e.g. if a majority of users at a venue have "liked" a particular band in their social network profiles).

Geolocation monitoring service **220** may comprise a communication engine **226** for communicating with portable devices **200**, computing devices at venues or provided by venue operators, or a computing device providing a web site or web service for applications as discussed above. Communication engine **226** may comprise an application, service, server, daemon, routine, or other executable logic for receiving and parsing notifications, and transmitting geolocation monitoring or demographics information, and may comprise or communicate with a network stack or interface of the service **220**.

Referring now to FIG. **3**, illustrated is a flow chart of an embodiment of a method for time-based geolocation. In brief overview, at step **300**, a device may receive an identification of a geofenced region and a planned arrival time $t_{arrival}$. At step **302**, the device may determine if the current time $t_{current}$ is prior to a predetermined time period x before the planned arrival time $t_{arrival}$. If so, then the device may repeat step **302** at periodic intervals. If the current time is within the predetermined time period before the planned arrival time, then at step **304**, the device may determine the location of the device. At step **306**, the device may compare the location to the

geofenced region boundaries. If the device is not within the region, and the current time is not later than a planned departure time $t_{departure}$, then the device may wait for a time $t_{interval}$ at step **308**, and then may repeat steps **304-306**. If the current time is later than the planned departure time, the method may end and/or proceed with regard to a next region and arrival time at step **300**.

If the device is within the region, then at step **310**, the device may transmit a notification and/or location to a server or geolocation monitoring service. At step **312**, the device may wait for an interval $t_{interval(2)}$. If the current time is after the departure time, the method may end and/or proceed with regard to a next region and arrival time at step **300**. Otherwise, the device may repeat a location determination process of step **304'** and step **306'**. If the device is still within the region, then the device may repeat steps **310-312**. Otherwise, if the device has left the region, the device may transmit a departure notification to the server or geolocation monitoring service at step **310'**, and the method may end and/or proceed with regard to a next region and arrival time at step **300**.

Still referring to FIG. **3** and in more detail, at step **300**, a device may receive an identification of a geofenced region and a planned arrival time $t_{arrival}$. As discussed above, the geofenced region may be of any shape or size. The planned arrival time may comprise an event start time, a reservation time, or any other time. As discussed above, in some embodiments, the device may receive the identification from a user via a user interface, responsive to the user registering for an event, purchasing a ticket to an event, indicating attendance at an event or venue, or any other such operation.

In some embodiments, at step **302**, prior to the planned arrival time $t_{arrival}$ or prior to a predetermined time period x prior to the planned arrival time, the device may not determine a location. This may reduce battery and CPU utilization. Once the current time is equal to or later than the predetermined time period x prior the planned arrival time $t_{arrival}$, the device may begin determining the location and the method may proceed.

At step **304**, the device may determine a current location of the device. In some embodiments, as discussed above, the device may process GPS signals to identify geographic coordinates of the device. In other embodiments, the device may process cellular signals, WiFi signals, or other signals. In many embodiments, the device may transmit a query to a location service provider with parameters of detected signal types, frequencies, and/or strengths, and may receive coordinates of the device. In other embodiments, the device may consult an internal database of signal origins and may triangulate the coordinates of the device accordingly. In many embodiments, the device may determine a current location of the device using an API provided by an operating system of the device.

At step **306**, the device may compare the coordinates or current location of the device to the boundaries of the geofenced region. As discussed above, in some embodiments, the geofenced region may be identified via a bitmap or array, and the device may identify a point within the bitmap or array as corresponding to its coordinates and determine whether it lines within the geofenced region. In other embodiments, the device may determine mathematically whether its current location lies within the geofenced region, such as comparing the distance between the coordinates of the device and the center of a geofence circle to a radius of the circle. If the device determines that it is not within the region, and more time exists before a planned departure time or an end of the event $t_{departure}$, then the device may wait a predetermined query interval $t_{interval}$ at step **308**. As discussed above, this may be a default query interval, or may be a higher frequency query interval to provide finer temporal resolution. Upon expiration of the query interval, the device may repeat steps **304** and **306**. If the current time is after the planned departure time or event end time, then in some embodiments, the device may stop determining the location of the device and may return to a start or waiting state. In other embodiments, such as if the user has registered for a later event, the device may return to step **300** with the new event location as the region and new event start time as $t_{arrival}$.

If the device determines that it has entered the region, then at step **310**, the device may transmit a notification to a server or geolocation monitoring service. As discussed above, the notification may comprise an HTTP POST request, an SMS communication, or any other type and form of communication. The notification may include a device identifier, user identifier, coordinates of the device, and/or any other information, as discussed above.

At step **312**, the device may wait for an interval $t_{interval(2)}$. This may be the same as $t_{interval}$, as discussed above in connection with default and high frequency queries **104***b* and **106** of FIG. **1**C or may be a different interval, as discussed above in connection with hybrid query frequency **108**. The interval may be shorter, to provider greater temporal resolution, or may be longer, to conserve battery and CPU utilization. In some embodiments, in response to the transmission of location at step **310**, the geolocation monitoring service may transmit a new $t_{interval(2)}$ for the device to use, as discussed above.

If after waiting at step **312**, the current time is after the event end or planned departure time, then the method may end and/or proceed with regard to a next region and arrival time at step **300**. If the current time is prior to the event end or planned departure time, then the device may repeat steps **304** and **306** (shown as steps **304'** and **306'**) as discussed above. If the device is still within the region, then device may repeat steps **310-312**. If, however, the device is no longer within the region, then the device may transmit a departure notification to the server at step **310'**. The departure notification may be similar or identical to an arrival or location notification, with coordinates indicating the device is outside of the region, or may be different. For example, notifications may include flags to indicate arrival, departure, or that the device is still within the region and is sending an update or refresh to the service (to indicate that the device is not lost or has powered off). Furthermore, although not illustrated, as discussed above, in some embodiments, the method may proceed from step **310'** to repeated iterations of steps **304-308**, in case the user re-enters the geofenced region.

Accordingly, through the above-discussed systems and methods, devices may utilize geolocation with time-based parameters to reduce battery and CPU usage, and/or provide enhanced temporal resolution within a time window of interest, and may notify a geolocation monitoring service which may be configured to monitor devices within a region for entry and departure.

B. Embodiments of Methods and Systems for Comparative Geofencing

Conventional geofencing allows reference to only one space at a time. This may make it difficult to compare one geofenced area to similar geofenced areas nearby. Even in some instances with overlapping geofences, devices are typically associated with only one geofence at a time, with a most-recently entered region having priority. As the device typically maintains awareness of only its own location, it

lacks knowledge of other devices and cannot make meaningful determinations or comparisons about regions.

Accordingly, in some embodiments, a geolocation monitoring service, such as embodiments of the service discussed above, may receive notifications from a plurality of devices and may maintain demographic information of the devices in each region. In some embodiments, each device may know of an overall monitored area or broad region geofence, and the geolocation monitoring service may identify subregions within the broad region and associated devices with such subregions. This may allow each device to simply operate as if only the larger geofenced region existed and provide updates of coordinates to the monitoring service, without needing advanced capabilities or additional geofence knowledge.

For example, referring to FIG. **4**A, illustrated is a diagram of an embodiment of comparative geofences. As shown, an overall region may be defined by a first geofence A **400**A. One or more subregions **400**B-**400**D may be defined within the overall region. The region and subregions may be of any shape and size, as shown. For example, a subregion may comprise a restaurant, nightclub, or individual building, while a region may comprise a neighborhood, street, campus, city, or any other size area. In some embodiments, a subregion may be a single room within a building or smaller, depending on location information resolution.

The monitoring service may receive notifications from devices **200** on entry or departure from the overall geofence **400**A, as well as periodic updates of coordinates within the overall geofence from devices remaining in the area, using the methods and systems discussed above. The monitoring service may identify from location information sent with a notification that a device **200** is within a particular subregion **400**B-**400**D, and may update statistics about each subregion accordingly.

As discussed above, devices **200'** external to the overall region **400**A may not transmit notifications to the monitoring service in many embodiments, reducing battery requirements for devices of users that have not yet arrived at the region or have departed.

Referring briefly to FIG. **4**B, illustrated is a exemplary table of an embodiment of demographics comparison for comparative geofences. As shown, the monitoring service may maintain statistics for each subregion **400**B-**400**D, including the number of devices (and accordingly users) in each subregion, as well as demographics information or ratios. For example, the monitoring service may determine, from stored user information or user profiles and/or information received in the notification, a gender ratio or percentage for a subregion, an average age or an age range, an average level of educational attainment, a majority preference of music, an average income level, or any other type and form of information. This information may be provided to devices to display to users, including devices of users who are considering visiting the region or subregion. For example, a user may utilize a user interface of a device to select an event or venue to attend, responsive to their preference regarding displayed demographic information about each event or venue.

FIG. **5** is a flow chart of an embodiment of a method for comparative geofencing and demographics tracking. In brief overview, at step **500**, a geolocation monitoring service, such as one executed by a computing device **220** or server farm or cloud of computing devices, may receive an identification of a region and a plurality of subregions of the region, such as a first region, a second region distinct from the first region, and a third region including the first region and second region. At step **502**, the geolocation monitoring service may receive a

notification from a device of arrival, departure, or an update or refreshed location, or may receive no notification. If the geolocation monitoring service receives no notification, then step **502** may repeat.

In some embodiments, if the geolocation monitoring service receives an arrival notification from a device, then at step **504***a*, the geolocation monitoring service may receive or retrieve user information. At step **506***a*, the geolocation monitoring service may identify a subregion (e.g. the first or second region) that the device is in, based on coordinates received in the notification. At step **508***a*, the geolocation monitoring service may increment a corresponding subregion tally.

If the geolocation monitoring service receives a departure notification from a device, then in some embodiments, and in a similar process to that discussed above, at step **504***b*, the geolocation monitoring service may receive or retrieve user information. At step **506***b*, the geolocation monitoring service may identify a subregion (e.g. the first or second region) that the device has left, based on cached or stored information from a previously received notification from the device. At step **508***b*, the geolocation monitoring service may decrement the corresponding subregion tally.

Optionally, in some embodiments (as shown in dashed line), the geolocation monitoring service may receive a refresh notification or updated location information from the device. At step **504***c*, the geolocation monitoring service may receive or retrieve user information. At step **506***c*, the geolocation monitoring service may identify a subregion (e.g. the first or second region) that the device is in, based on coordinates received in the notification and a subregion that the device was previously in, based on cached or stored information from a previously received notification from the device. At step **508***c*, the geolocation monitoring service may verify the corresponding subregion tally if the new subregion and previous subregion are the same, or may decrement a previous subregion tally and increment a new subregion tally, if the device has moved.

At step **510**, the geolocation monitoring service may compare subregion demographics of the incremented or decremented subregion to other subregions, and at step **512**, the geolocation monitoring service may transmit a comparison metric to one or more devices, including portable devices, web servers, or other devices.

Still referring to FIG. **5** and in more detail, at step **500**, the geolocation monitoring service may receive an identification of a plurality of geofenced regions, such as a first region, a second region distinct from the first region, and a third region that overlaps or includes the first and second regions. The regions may be of any size and shape, and may be defined in various ways including paths, boundaries, radii, or as arbitrary shapes via a bitmap or data array. The geolocation monitoring service may receive the identification of regions from an administrator or operator of the service, or may receive the identification of regions from a user. For example, in one such embodiment, a user, such as a concert promoter, may create an event for the system, such as a local band performance, and may indicate that the event is occurring at a building at a particular street address. The geolocation monitoring service may interpret this as a geofenced region with coordinates centered on the address and a radius of a predetermined size, such as 20 meters. In another embodiment, the system may present a map to the user, and the user may draw or otherwise define a geofence region on the map. In some embodiments, the overall region or geofence that includes the other geofences may be dynamically generated by the geolocation monitoring service. For example, the region may be gener-

ated as a circle centered on a centroid of all of the other defined geofences, with a radius equal to the distance from the centroid to the farthest point within a subregion geofence. In many embodiments, the geolocation monitoring service may receive identification of the regions a significant time prior to step **502**, for example, during configuration of the system or when setting up events.

At step **502**, the geolocation monitoring service may receive a notification from a device. As discussed above, the notification may be of any type and form, such as an HTTP data packet comprising a GET or POST request. The notification may include parameters or data fields explicitly defining the notification as an arrival, departure, or update or refresh, or this status may be implicit. For example, the first notification received from a device may logically be an arrival notification, while a notification received from a device with coordinates outside of a region may logically be a departure notification. In some embodiments, the geolocation monitoring service may not receive update or refreshed notifications, to reduce battery and bandwidth requirements of the devices or reduce load on the geolocation monitoring service. Notifications may include device identifiers, user identifiers or names, device coordinates, IP addresses, profile identifiers, demographic information, flags indicating arrival, departure, or refresh, or any other type and form of information.

If the notification is an arrival notification, or if the notification is the first notification received from a device (e.g. if the geolocation monitoring service does not have the device identifier stored in a cache or data table corresponding to the region or a subregion), then at step **504***a*, the geolocation monitoring service may receive or retrieve user information. For example, in some embodiments, the geolocation monitoring service may receive user information in the notification, such as a user profile, user identifier, user demographic information, or any other such information. In other embodiments, the geolocation monitoring service may retrieve user information from a user profile in a database, or from a social network service, such as Facebook. In such embodiments, the notification may include a user identifier such as a user ID or account name, and the geolocation monitoring service may retrieve a profile for the corresponding account.

At step **506***a*, the geolocation monitoring service may identify a subregion or region that the device is in, responsive to coordinates in the notification. For example, the geolocation monitoring service may compare coordinates received in the notification to a plurality of geofence regions to determine which geofence the device is within. As discussed above, geofences may be overlapping, or an overall region may include one or more subregions. The geolocation monitoring service may identify the smallest subregion that contains the coordinates of the device in the notification.

At step **508***a*, in some embodiments, the geolocation monitoring service may increment a subregion tally for the identified subregion. The geolocation monitoring service may maintain a data record or records for each subregion, identifying a count of devices in the subregion, which may be incremented as devices arrive and decremented as devices leave. In some embodiments, the geolocation monitoring service may also update other demographic information about the subregion, including gender ratios, average ages or age ranges, or any other type and form of demographic information, as discussed above. The geolocation monitoring service may utilize information retrieved in a user profile at step **504***a* to update the subregion demographic record. To avoid computationally expensive recalculation, particularly with a large number of devices in a subregion, in some embodiments, a value and an associated parameter may be stored, such as an average age and a number of users, such that the average may be quickly updated by multiplying the previous average by the previous number of users, adding the new user's age to the result, and dividing by the new number of users.

In a similar process, if the notification is a departure notification, then the geolocation monitoring service may receive user information **504***b*. In some embodiments, the geolocation monitoring service may cache user information received or retrieved at step **504***a* when a device arrives or first notifies the geolocation monitoring service. The geolocation monitoring service may retrieve the cached user information at step **504***b*, reducing the requirement to re-retrieve the data from a social networking service or other external system.

At step **506***b*, the geolocation monitoring service may identify a subregion that the device has departed. As discussed above, the geolocation monitoring service may cache a previous notification from the device and/or an identification of the device as within a subregion. For example, in one embodiment, the geolocation monitoring service may maintain a table of user or device identifiers for each subregion. Upon receipt of a departure notification, the geolocation monitoring service may search the tables to find the corresponding device or user identifier in a subregion table. In other embodiments, the geolocation monitoring service may associate the device or user identifier with a subregion identifier. For example, the device or user identifier may be used as the index of a list or table, and have a corresponding entry with a data value associated with the subregion, such as a subregion identifier. This may allow for efficient determinations of region associations.

At step **508***b*, the geolocation monitoring service may decrement a tally associated with the identified subregion. In some embodiments, the geolocation monitoring service may update demographics of the region, such as updating a gender ratio or average age. As discussed above, in one embodiment, averages may be updated without requiring recalculation by storing the average along with a number of users parameter.

In some embodiments, devices may periodically send update or refresh notifications to the geolocation monitoring service. This may be done to indicate that the device has not powered off or stopped communicating, as, in some embodiments, if the geolocation monitoring service receives an arrival notification for a device but receives no further notifications from the device within a predetermined period of time or a record expiration time, the geolocation monitoring service may remove the device from the region list, assuming that the user has left without the device transmitting a departure notification. Expiration times may be quite long, such as one hour, four hours, or any other value. Update or refresh notifications may also be helpful for instances in which a user moves from one subregion to another without leaving the overall region, such as moving from one club to another club, both on the same street.

In some embodiments, the geolocation monitoring service may retrieve cached user information corresponding to the device or user identifier at step **504***c*. The geolocation monitoring service may identify at step **506***c* a previous subregion associated with the device, and may determine whether the device is still within the same subregion based on coordinates received in the notification. If so, then at step **508***c*, the geolocation monitoring service may update an expiration timer associated with the device, but need not update demographic information. If the device has moved to a different subregion, then at step **508***c*, the geolocation monitoring service may perform steps **508***b* and **508***a* for the previous and new subregion, respectively.

At step **510**, in many embodiments, subregion demographics may be compared. The comparison may comprise identi-

fying demographic differences between different subregions and ranking or ordering the subregions accordingly. For example, in one such embodiment, subregions may be ranked by gender ratios. Such rankings or orderings may be transmitted to the devices or other computing devices or used to update a website at step **512**, allowing users and venue operators to make attendance or operational decisions dynamically based on real-time demographic data.

C. Embodiments of Exemplary Computing Devices

FIG. **6** is a block diagram of an exemplary computing device useful for practicing the methods and systems described herein. The various devices **200**, **220**, may be deployed as and/or executed on any type and form of computing device, such as a computer, network device or appliance capable of communicating on any type and form of network and performing the operations described herein. The computing device may comprise a laptop computer, desktop computer, virtual machine executed by a physical computer, tablet computer, such as an iPad tablet manufactured by Apple Inc. or Android-based tablet such as those manufactured by Samsung, Inc. or Motorola, Inc., smart phone or PDA such as an iPhone-brand/iOS-based smart phone manufactured by Apple Inc., Android-based smart phone such as a Samsung Galaxy or HTC Droid smart phone, or any other type and form of computing device. FIG. **6** depicts a block diagram of a computing device **600** useful for practicing an embodiment of the devices **200**, **220** or device of a social media provider or service in communication with a geolocation monitoring service **220**. A computing device **600** may include a central processing unit **601**; a main memory unit **602**; a visual display device **624**; one or more input/output devices **630***a*-**630***b* (generally referred to using reference numeral **630**), such as a keyboard **626**, which may be a virtual keyboard or a physical keyboard, and/or a pointing device **627**, such as a mouse, touchpad, or capacitive or resistive single- or multi-touch input device; and a cache memory **640** in communication with the central processing unit **601**.

The central processing unit **601** is any logic circuitry that responds to and processes instructions fetched from the main memory unit **602** and/or storage **628**. The central processing unit may be provided by a microprocessor unit, such as: those manufactured by Intel Corporation of Santa Clara, Calif.; those manufactured by Motorola Corporation of Schaumburg, Ill.; those manufactured by Apple Inc. of Cupertino Calif., or any other single- or multi-core processor, or any other processor capable of operating as described herein, or a combination of two or more single- or multi-core processors. Main memory unit **602** may be one or more memory chips capable of storing data and allowing any storage location to be directly accessed by the microprocessor **601**, such as random access memory (RAM) of any type. In some embodiments, main memory unit **602** may include cache memory or other types of memory.

The computing device **600** may support any suitable installation device **616**, such as a floppy disk drive, a CD-ROM drive, a CD-R/RW drive, a DVD-ROM drive, tape drives of various formats, USB/Flash devices, a hard-drive or any other device suitable for installing software and programs such as any client agent **620**, or portion thereof. The computing device **600** may further comprise a storage device **628**, such as one or more hard disk drives or redundant arrays of independent disks, for storing an operating system and other related software, and for storing application software programs such as any program related to the client agent **620**.

Furthermore, the computing device **600** may include a network interface **618** to interface to a Local Area Network (LAN), Wide Area Network (WAN) or the Internet through a variety of connections including, but not limited to, standard telephone lines, LAN or WAN links (e.g., Ethernet, T1, T3, 56 kb, X.25), broadband connections (e.g., ISDN, Frame Relay, ATM), wireless connections, (802.11a/b/g/n/ac, BlueTooth), cellular connections, or some combination of any or all of the above. The network interface **618** may comprise a built-in network adapter, network interface card, PCMCIA network card, card bus network adapter, wireless network adapter, USB network adapter, cellular modem or any other device suitable for interfacing the computing device **600** to any type of network capable of communication and performing the operations described herein.

A wide variety of I/O devices **630***a*-**630***n* may be present in the computing device **600**. Input devices include keyboards, mice, trackpads, trackballs, microphones, drawing tablets, and single- or multi-touch screens. Output devices include video displays, speakers, headphones, inkjet printers, laser printers, and dye-sublimation printers. The I/O devices **630** may be controlled by an I/O controller **623** as shown in FIG. **6**. The I/O controller may control one or more I/O devices such as a keyboard **626** and a pointing device **627**, e.g., a mouse, optical pen, or multi-touch screen. Furthermore, an I/O device may also provide storage **628** and/or an installation medium **616** for the computing device **600**. The computing device **600** may provide USB connections to receive handheld USB storage devices such as the USB Flash Drive line of devices manufactured by Twintech Industry, Inc. of Los Alamitos, Calif.

The computing device **600** may comprise or be connected to multiple display devices **624***a*-**624***n*, which each may be of the same or different type and/or form. As such, any of the I/O devices **630***a*-**630***n* and/or the I/O controller **623** may comprise any type and/or form of suitable hardware, software embodied on a tangible medium, or combination of hardware and software to support, enable or provide for the connection and use of multiple display devices **624***a*-**624***n* by the computing device **600**. For example, the computing device **600** may include any type and/or form of video adapter, video card, driver, and/or library to interface, communicate, connect or otherwise use the display devices **624***a*-**624***n*. A video adapter may comprise multiple connectors to interface to multiple display devices **624***a*-**624***n*. The computing device **600** may include multiple video adapters, with each video adapter connected to one or more of the display devices **624***a*-**624***n*. Any portion of the operating system of the computing device **600** may be configured for using multiple displays **624***a*-**624***n*. Additionally, one or more of the display devices **624***a*-**624***n* may be provided by one or more other computing devices, such as computing devices **600***a* and **600***b* connected to the computing device **600**, for example, via a network. These embodiments may include any type of software embodied on a tangible medium designed and constructed to use another computer's display device as a second display device **624***a* for the computing device **600**. One ordinarily skilled in the art will recognize and appreciate the various ways and embodiments that a computing device **600** may be configured to have multiple display devices **624***a*-**624***n*.

A computing device **600** of the sort depicted in FIG. **6** typically operates under the control of an operating system, such as any of the versions of the Microsoft® Windows operating systems, the different releases of the Unix and Linux operating systems, any version of the Mac OS® for Macintosh computers, any embedded operating system, any

real-time operating system, any open source operating system, any proprietary operating system, any operating systems for mobile computing devices, or any other operating system capable of running on the computing device and performing the operations described herein.

The computing device **600** may have different processors, operating systems, and input devices consistent with the device. For example, in one embodiment, the computer **600** is an Apple iPhone or Motorola Droid smart phone, or an Apple iPad or Samsung Galaxy Tab tablet computer, incorporating multi-input touch screens. Moreover, the computing device **600** can be any workstation, desktop computer, laptop or notebook computer, server, handheld computer, mobile telephone, any other computer, or other form of computing or telecommunications device that is capable of communication and that has sufficient processor power and memory capacity to perform the operations described herein.

D. Exemplary User Interface

FIGS. **7**A-**7**D are exemplary screenshots of an embodiment of a user interface for defining events and reviewing tracked demographics. The screenshots are provided merely to illustrate one potential design or embodiment of the user interface, and one of skill in the art may readily appreciate that other designs may be implemented.

Referring first to FIG. **7**A, shown is an exemplary screenshot of an embodiment of a user interface **700** for selecting an event and viewing demographic information. In some embodiments, the user interface **700** may be displayed to users via a smart phone or tablet application, while in other embodiments, the user interface **700** may be provided in a webpage or other interface. The user interface **700** may allow a user to select from multiple event types, subtypes, dates, locations, or search for a specific event. In some embodiments, the user interface **700** may show multiple events **702***a*-**702***c*, including featured events or events for which an advertiser has paid a premium for highlighted placement within the user interface. Non-featured events may be ranked by distance from the device's current location, time to the event, amount of free spaces or unpurchased tickets, price, or any other metric. In some embodiments, demographic information **704***a*-**704***c* may be shown, such as a gender ratio (shown in different shadings of gray, but more typically displayed in colors such as pink and blue, or associated with distinct icons).

FIG. **7**B is an exemplary screenshot of an embodiment of an interface **710** for creating an event. Venue operators or promoters may use the interface to define events for display and selection by users via interface **700**. As shown, an operator may provide an event name, venue name, address, start and/or end time and date, category, subcategory, price range, logo, description, special offer for users of the system, or any other information. In some embodiments, the operator may select options for repeating the event, linking the event to social networking services or social media, adding additional advertising, or having the event appeared in a featured spot in interface **700**.

In some embodiments, the operator may select to record detailed demographic information. As shown in the exemplary screenshot of FIG. **7**C, the user interface **715** may allow an operator to purchase detailed attendance statistics of attendees or registered users for the event, including anticipated or actual, real-time data.

In some embodiments, an operator may be charged a fee to list an event. As shown in the exemplary screenshot of FIG. **7**D, a user interface **720** may present a payment screen with a price dynamically calculated based on selected options, advertising selections, or other features.

FIG. **7**E is an exemplary screenshot of a dashboard user interface **750** for an operator of an event, displaying detailed demographic information for an event **752**. Information about the event **754** may be displayed, along with demographic statistics **756**-**766**. For example, the dashboard **750** may display gender ratios or numbers either in the aggregate **756**, or by instance of an event, weekly, or monthly **758**. The dashboard **750** may display further demographic information **760**, **762**, including the number of unique users, retention rates or how often users attend multiple events, age ranges or averages, or other such information. The dashboard **750** may also show regional demographic information **764**, as well as how many users viewed the event or selected to receive additional information about the event. In some embodiments, the dashboard **750** may provide a link to social media discussions about the event **768** such as a Twitter hashtag or Facebook group, or may display reviews of the event **770**.

It should be understood that the systems described above may provide multiple ones of any or each of those components and these components may be provided on either a standalone machine or, in some embodiments, on multiple machines in a distributed system. The systems and methods described above may be implemented as a method, apparatus or article of manufacture using programming and/or engineering techniques to produce software embodied on a tangible medium, firmware, hardware, or any combination thereof. In addition, the systems and methods described above may be provided as one or more computer-readable programs embodied on or in one or more articles of manufacture. The term "article of manufacture" as used herein is intended to encompass code or logic accessible from and embedded in one or more computer-readable devices, firmware, programmable logic, memory devices (e.g., EEPROMs, ROMs, PROMs, RAMs, SRAMs, etc.), hardware (e.g., integrated circuit chip, Field Programmable Gate Array (FPGA), Application Specific Integrated Circuit (ASIC), etc.), electronic devices, a computer readable non-volatile storage unit (e.g., CD-ROM, floppy disk, hard disk drive, etc.). The article of manufacture may be accessible from a file server providing access to the computer-readable programs via a network transmission line, wireless transmission media, signals propagating through space, radio waves, infrared signals, etc. The article of manufacture may be a flash memory card or a magnetic tape. The article of manufacture includes hardware logic as well as software or programmable code embedded in a computer readable medium that is executed by a processor. In general, the computer-readable programs may be implemented in any programming language, such as LISP, PERL, C, C++, C#, PROLOG, or in any byte code language such as JAVA. The software programs may be stored on or in one or more articles of manufacture as object code.

What is claimed:

1. A method for tracking locations of a plurality of devices within overlapping geofences, comprising:

receiving, by a location analyzer executed by a computing device, an identification of (i) a first region defined by a first geofence; (ii) a second region defined by a second geofence distinct from the first geofence; and (iii) a third region defined by a third geofence including the first region and second region;

receiving, by the location analyzer, a plurality of arrival notifications from a corresponding plurality of devices, each arrival notification sent by each device responsive to said device determining it has entered the third geofence;

receiving, by the location analyzer, user information for a user of each of the plurality of devices;

identifying, by the location analyzer, a first subset of the plurality of devices that are within the first region and a second subset of the plurality of devices that are within the second region;

comparing, by the location analyzer, user information of the users of the first subset of the plurality of devices and user information of the users of the second subset of the plurality of devices; and

transmitting, by the location analyzer to a second computing device, a comparison metric identifying a difference between users of the first subset of the plurality of devices and users of the second subset of the plurality of devices.

2. The method of claim **1**, wherein the first region and the second region do not overlap.

3. The method of claim **1**, wherein each arrival notification is sent by each device further responsive to a current time being within a predetermined time period of a planned arrival time.

4. The method of claim **1**, wherein each arrival notification comprises a geographic location of the corresponding device.

5. The method of claim **1**, further comprising receiving, by the location analyzer, one or more current device locations from a corresponding one or more of the plurality of devices, sent by each device responsive to said device determining it is still within the third geofence.

6. The method of claim **5**, further comprising:

re-identifying a first subset of the plurality of devices that are within the first region and a second subset of the plurality of devices that are within the second region based on the received one or more current device locations;

re-comparing, by the location analyzer, user information of the users of the first subset of the plurality of devices and user information of the users of the second subset of the plurality of devices; and

transmitting, by the location analyzer to the second computing device, an updated comparison metric identifying a change in the difference between users of the first subset of the plurality of devices and users of the second subset of the plurality of devices.

7. A system for tracking locations of a plurality of devices within overlapping geofences, comprising:

a computing device comprising a processor executing a location analyzer configured for:

receiving an identification of (i) a first region defined by a first geofence; (ii) a second region defined by a second geofence distinct from the first geofence; and (iii) a third region defined by a third geofence including the first region and second region,

receiving a plurality of arrival notifications from a corresponding plurality of devices, each arrival notification sent by each device responsive to said device determining it has entered the third geofence,

receiving user information for a user of each of the plurality of devices,

identifying a first subset of the plurality of devices that are within the first region and a second subset of the plurality of devices that are within the second region,

comparing user information of the users of the first subset of the plurality of devices and user information of the users of the second subset of the plurality of devices, and

transmitting, to a second computing device, a comparison metric identifying a difference between users of the first subset of the plurality of devices and users of the second subset of the plurality of devices.

8. The system of claim **7**, wherein the first region and the second region do not overlap.

9. The system of claim **7**, where each arrival notification is sent by each device further responsive to a current time being within a predetermined time period of a planned arrival time.

10. The system of claim **7**, wherein each arrival notification comprises a geographic location of the corresponding device.

11. The system of claim **7**, wherein the location analyzer is further configured for receiving one or more current device locations from a corresponding one or more of the plurality of devices, sent by each device responsive to said device determining it is still within the third geofence.

12. The system of claim **11**, wherein the location analyzer is further configured for:

re-identifying a first subset of the plurality of devices that are within the first region and a second subset of the plurality of devices that are within the second region based on the received one or more current device locations,

re-comparing user information of the users of the first subset of the plurality of devices and user information of the users of the second subset of the plurality of devices, and

transmitting, to the second computing device, an updated comparison metric identifying a change in the difference between users of the first subset of the plurality of devices and users of the second subset of the plurality of devices.

13. A method for tracking locations of a plurality of devices within overlapping geofences, comprising:

receiving, by a portable computing device, an identification of a first geofence defining a first region;

determining a current location of the portable computing device;

comparing the current location of the portable computing device to the identified first geofence; and

transmitting, by the portable computing device to a second computing device, an arrival notification, responsive to determining that the current location of the portable computing device is within the identified first region, the arrival notification including an identification of the current location of the portable computing device within one of a plurality of subregions of the first region defined by a corresponding plurality of geofences.

14. The method of claim **13**, further comprising:

receiving, by the portable computing device from the second computing device, an identification of one or more users of other portable computing devices within the same one of the plurality of subregions of the first region as the portable computing device.

15. The method of claim **14**, wherein the identification of the one or more users of other portable computing devices comprises an identification of a gender ratio of the one or more users within the same one of the plurality of subregions.

16. The method of claim **13**, further comprising:

transmitting a current location of the portable computing device to the second computing device, at a predetermined frequency, until the portable computing device determines that the current location of the portable computing device is no longer within the identified first region.

17. The method of claim **13**, further comprising:

transmitting a current location of the portable computing device to the second computing device, at a predetermined frequency, until expiration of a predetermined time period.

18. The method of claim **13**, further comprising:

receiving, by the portable computing device, an identification of a planned arrival time;

identifying, by the portable computing device, that a current time is within a predetermined period of time before the planned arrival time; and

wherein determining a current location of the portable computing device is performed responsive to the identification that the current time is within the predetermined time period before the planned arrival time.

19. The method of claim **18**, further comprising, prior to transmitting the arrival notification, repeating determining the current location of the portable computing device and comparing the current location of the portable computing device to the identified first geofence at a predetermined frequency, responsive to determining that the current location of the portable computing device is outside of the identified first region.

20. The method of claim **13**, wherein the arrival notification includes an identification of a user of the portable computing device.

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